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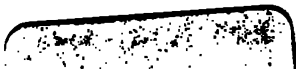
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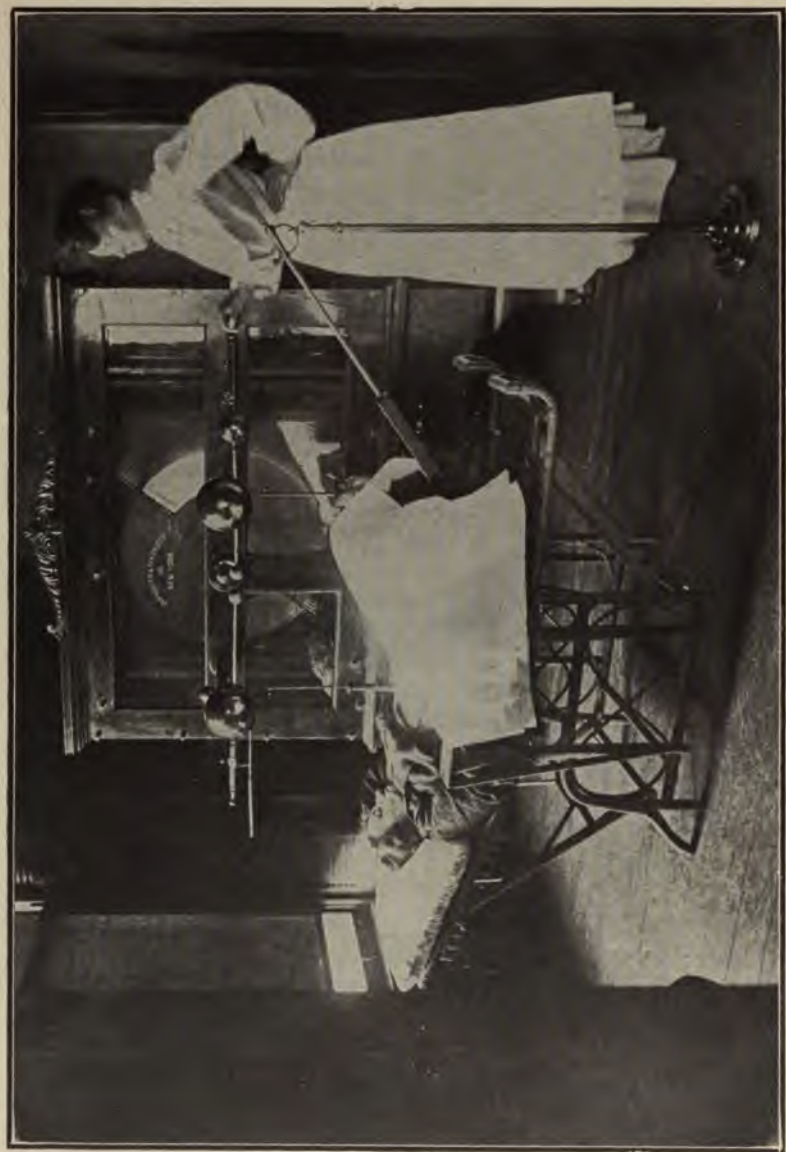


PLATE I. Static Induced Current. One Large Metal Electrode over Abdomen Connected to Pole Having Small Leyden Jar, and Vacuum Tube in Vagina Connected to Outer Coating of Large Leyden Jar.

Currents of High Potential

Of High and Other Frequencies

BY

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PREFACE

THE study of the application of currents of high potential associated with variations in current strength and frequency as applied in therapeutics, is engaging the attention of the medical profession as never before. Many valuable treatises have been contributed to the subject of currents of *high frequency and great potential*, but in no work published has due attention been accorded to *great potential* in association with the *lower rates* of frequency.

In view of the marked contrast in the physiological effects, in many essential particulars, of the different frequencies, and for the purpose of calling attention to the relative actions of currents derived from different types of apparatus, it is purposed here to consider the high-potential currents broadly.

The author is sensible of the fact that in a field to which so many able writers are contributing, there is certain to be a diversity of opinion and development of new methods and apparatus. Noting that the value of many features and methods which have been demonstrated in his private and clinic practice has not been recognized by other writers, he is induced to add the same to the literature. Enough consideration has not been accorded by previous writers to the high-potential currents of the lesser rates of frequency, which have been demonstrated

to exert the most favorable effects upon acute and chronic inflammatory conditions, especially those in which no germs are present. It is the writer's object to show the reasons for contrasting these currents, and to endeavor to call attention to the importance of a degree of discrimination in other particulars not generally observed.

The vacuum tubes which have come into such general use during the past two years as one of the mediums for administering high-potential currents call for more consideration than has been previously accorded them. With the object of calling to the mind of the profession the broad scope of indications for their employment, many designs for special cases are presented as suggestions, with the realization that they will, in a few years, be replaced by others in many instances better adapted to many conditions.

WILLIAM BENHAM SNOW.

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HIGH-POTENTIAL CURRENTS OF HIGH AND OTHER FREQUENCIES

CHAPTER I

INTRODUCTION

THE study of currents of high potential has opened a field of far-reaching scope and possibilities in therapeutics unrecognized by most physicians, even those who stand high in the councils of the profession.

A new science has developed beyond the appreciation of many great men who have been investigating in fields of diagnosis, pathological investigation, and other departments of professional research.

The study of the employment of electrical currents of high potential and small quantity, which are fraught with far less danger and uncertainty than drugs, is an enchanting one as employed in therapeutics, associated as they are with results which in many instances overshadow all precedents. With such currents the laws of action and control are clear, positive, and unvarying, and their administration is without danger or uncertainty, in the hands of those who are familiar with them.

The technical study of the physics and features of construction of static machines, coils, resonators, and other transformers, entailing time and thorough investigation, is invaluable to the student who would master every detail of the subject. The practical knowledge, however, of the principles of action of electric currents and their means of control, in conjunction with a knowledge of their indications and methods of application, are the *requisite* essentials for the physician who would successfully employ them. This knowledge alone will suffice for their intelligent application.

It is not, therefore, the writer's intention in this volume to enter into the details and varying features of construction of the different apparatus employed as sources of electrical energy, but to discuss the qualities of the currents required, and at the same time to urge the demand for standards of efficiency for electrical discharges to meet varied therapeutic indications.

The disposition of numerous writers to pay tribute to the currents of *high potential* and *great frequency* and to ignore the high-potential currents and discharges of *lesser frequency* is to be regretted, for the field of application for currents of *high potential* and *low frequencies* is as large, if not larger, than the former. It is certain, however, that there are indications for the employment of high-potential currents of various frequencies.

The disposition at the present time is to employ very high frequencies without reference to any standard of indication or requirement, which is not consistent with any scientific recognition of the laws of vibration. The

use of such currents without the establishment of definite rates to meet various indications tends to the institution of methods which are not scientific. Of high-frequency apparatus which are now manufactured, no two, except by accident, produce identical frequencies.

Those who are familiar with the properties of induced vibration as affecting animal tissue (and of these principles we are treating when we consider current frequencies) are aware that there are laws of accord in the vibration of various tissues and organs, the rates of which, however, scientific investigation may never discover. Unless such discoveries are made as will determine these rates of accord, the discussion of high frequencies except in connection with means of peripheral stimulation, which seems to be the field for present application, is unscientific.

It is a problem that would call for a long series of comparative experiments and the comparison of results before any definite standard could be established. The effort to discover such standards of frequency for electrical discharges is at present rendered doubly difficult because there are no means of measuring, determining, or controlling the varying rates of frequency.

The oscillations as produced by electrical discharges produce different effects characteristic of vibration as is evidenced by sound, color, heat, and sensations of vibration induced. It is evident that these various rates of vibration or oscillation are not synchronous nor do they correspond with the conditions of frequency under which they are produced, for other conditions, such as the ten-

sion and density of the media in which they take place, influence in varying degrees the rates of vibration. This is evidenced when the same frequencies are employed in connection with vacuum tubes having different degrees of vacua. It would seem, then, that the study of electrical phenomena as associated with vibration is one not depending so much upon the frequency as upon the potential, varied by the different media in which the discharges take place. If this be true, the study of frequencies in relation to physiological effects is still farther complicated, leading to a study of their actions in association with the phenomena of heat, light, and the less frequent rates of vibration associated with the varying pitch of sounds produced.

The sensible vibrations—those which are appreciated by the sense of touch—are of the lower rates of frequency and are capable, in the author's experience, of producing more profound physiological results on account of their greater amplitude and more forcible impact than the rates of vibration of the currents of higher frequency which experience would seem to indicate to act only superficially. The foregoing observations lead the writer to believe that the therapeutic application of high-potential currents must be considered more particularly from the standpoint of potential than frequency.

The potential or voltage of electrical discharges depends for its production, in accordance with the laws of electro-physics, upon definite and well-established principles. The number and length of windings in the secondary, and the character of windings as to fineness, and

quality of insulation, determine the electromotive force of the current produced, when derived from a Ruhmkorff coil. The rate of speed and the number and diameter of the revolving plates in a scientifically constructed static machine determine the potential and quantity of the current produced, the maximum being measured by a spark not exceeding one-half of the diameter of the revolving plate, which is produced, under favorable conditions, at a moderate rate of speed, an increase of speed in excess of the possibility of inducing a maximum spark, increasing the frequency of recurrent discharges.

CHAPTER II

THE STATIC WAVE-CURRENT, PRINCIPLES OF ACTION AND THERAPEUTIC INDICATIONS

THIS valuable electric modality has been known to the profession for so short a time that we believe that relatively few have appreciated its pronounced effects and scope of general utility.*

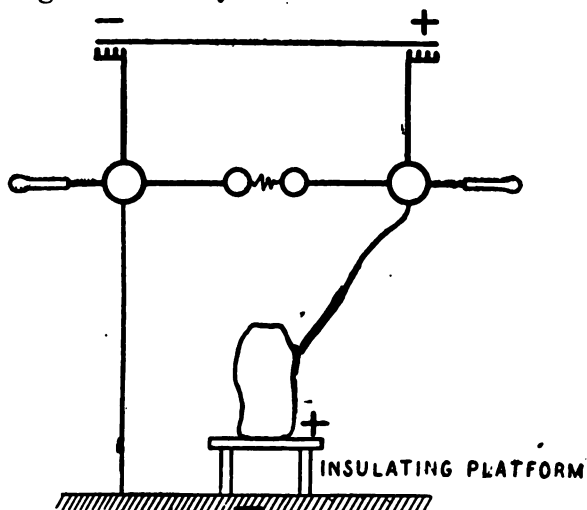


FIG. 1. Arrangement for the Static Wave-Current.

The arrangement for the current as shown in Fig. 1 was described by Jenks and Clarke in the report of the Com-

* This current was first published in the *Bulletin Officiel de la Société Française d'Électrothérapie* of January, 1899, and later in the *Electrical Engineer* of March 4 of the same year, and by the writer both in the *Medical Record* of March 3, 1900, and in the Transactions of the American Electro-Therapeutic Association for 1900.

mittee on Nomenclature as follows: "In this arrangement, which the Committee believes originated with Dr. W. J. Morton, one prime conductor of the static generator is grounded; the other is connected with an electrode applied to the patient, who is on an insulated stand. The current received by the patient is due to the spark discharge between the knobs of the prime conductors. The patient forms one coating of a Leyden jar condenser, the other coating of which is the earth and surrounding objects and walls connected electrically therewith."

"The greater part of the charge and resulting strain on the dielectric, air, will be found at those parts of the patient and floor or walls of the room that are nearest together."

"If the spark-gap be long, the time of charging by the small continuous current will also be comparatively long, because the potential must be raised to a high point in order to produce a long spark. The duration of the discharge, which will probably be an oscillatory one of relatively high frequency, because of the small capacity of the condenser, will be short. The small continuous charging current will flow through the patient without causing appreciable sensation. The sudden oscillatory discharge may flow over the surface of the patient because of its high frequency, and therefore without disagreeable effects. As the length of the spark-gap is diminished, the time and amount of charge becomes less, with a resulting diminution of sensation."

It will be observed that in the arrangement for the administration of this current the following provisions are

made: (1) *An insulated platform*, for best results having legs 8 to 9 inches in length, and being about two and one-half by four and one-half feet in size, should be provided. (2) *A grounding chain* or metallic cord connected to some metallic path to damp earth, for which the house gas or water pipes are usually employed. In cases where such facilities are not convenient, a wire running to a rod driven deep into the cellar bottom will prove equally as good. (3) *A spark-gap*—the current regulator of potential of delivery—the distinctive feature of the static currents—is usually allowed to discharge between the balls of the discharging rods. When, therefore, the *spark-gap* is referred to, it is usually considered to be in this position. (4) *The connecting cord* and a *metallic electrode* connecting the patient directly to one side of the Holtz machine—the side opposite the grounding—completes the provisions.

The *static machine* should give a steady, uniform output of current and be operated at a rate of speed which will not give a *great* frequency as suggested in the above paragraph; lest “a sudden oscillatory discharge might flow over the surface of the patient because of its high frequency.” Because in the administration of this current the physiological effects sought are those derived from the passing to and fro of the current, between the surface of the electrode and the whole surrounding surface of the body of the patient, surging back and forth, and from the local vibratory effects and muscular contraction induced in the tissues beneath the electrode.

The distinctive characteristics of the wave-current, it

will be observed from the above description, are peculiar.

(1) *It is a current of one polarity* (preferably the positive), administered to the patient from one side of the static machine, passing to and fro from the whole surface synchronous with the discharge at the spark-gap. (2) *The intensity of the discharge* depends to a marked degree upon the character of the grounding—a condition which it is not possible to effect with any current connected with a Ruhmkorff coil. (3) *The general diffusion* of this current, during the intervals between the charge and discharge of the current, are greater than from a current administered in any other manner with safety to the patient. (4) The current, when properly applied, is administered to the patient with the *absence* of any *disagreeable effects*, passing in and out of his body without any appreciable sensation except the moving of the hair, the vibratory influence, and the effects of muscular contraction. Care should be exercised to administer the treatment with the metallic electrode next to the skin of the patient, an intervening garment causing disagreeable burning sensations due to the passage of myriads of short sparks through the fabric. If the skin of the patient is very dry, at the commencement of an administration, there may be a burning sensation, due to the passage of short sparks through the dry epidermis. This is easily obviated by starting the administration with a short spark-gap, when shortly sufficient secretion will be induced to moisten the integument, or by first moistening the surface beneath the electrode.

The physiological effects of the wave-current suggest a

very wide range of application to therapeutics. In the first place, the current is absolutely innocuous,—harmless to the patient,—which makes it one of the most popular methods of applying electricity. This will be easily explained when we realize that the amperage is relatively so small that the possible damage to the patient from the quantity of current is reduced to a minimum—and that with a current of one polarity, though surging to and fro through the tissues, the electrolytic action is practically nil. Its effect, then, is purely mechanical with the added characteristics of electrical discharges. These effects are the induction of contractions which restore relaxed tissues to a condition of tonicity, in which condition they will persist for hours after the administration.

Upon metabolism, both local and general, the actions of this current are remarkable. The vibratory influence and recurrent intervals of contraction induce mechanically an activity of the end organs beneath the electrode stimulating secretion and excretion and tissue-building to a marked degree, and without harmful effects. Locally, conditions of *stasis* and stagnation are overcome, a local tonic condition of the arterioles is induced, promoting restoration to normal conditions where stasis has been present. These effects are not merely superficial but varied in their depth of penetration in proportion to the amplitude of the current, which is varied by increasing or slowing the speed of the machine and by lengthening or shortening the spark-gap. The physiological action, other things being equal, will depend to a large extent upon the character of the underlying subcutaneous

tissues. Layers of adipose or cellular tissue, owing both to the fact that they are poor conductors and muffle vibration, tend materially to interfere with the effects on the underlying muscular and glandular structures.

Muscular contraction, as suggested, may be induced to varying degrees from a *slight* vibratory tremor to a condition of extreme tetanus. The degree of contraction may be perfectly controlled by the operator, by varying the length of the spark-gap and to some extent by regulating the speed of the machine.

Vibration of a distinctly mechanical character is induced in consequence of the tissue contractions and by the influence of surrounding oppositely charged capacities, i. e., the walls of the room and objects surrounding the insulated platform, and may be intensified either by connecting the patient with any external insulated capacity, as a plate of metal suspended upon an insulated stand (see Fig. 2), or even by movements of the patient, as of the extremities, towards an oppositely charged capacity, as the opposite pole of the static machine, or walls of the room. The vibratory effect is undoubtedly also influenced by the sudden impact of the current discharging against the resisting skin, and the impulses of vibration are always synchronous with the discharge at the spark-gap. The depth to which vibratory impulses are transmitted, as with muscular contraction, will be varied by altering the length of the spark-gap, and the effect produced will depend largely upon the conditions of the underlying tissues,—a thick layer of fat offering

resistance to the current, and limiting the effects upon the muscular tissues.

Contraction of cell protoplasm is another undoubted effect produced by high-potential discharges at the site of administration. The degree or extent to which it is possible to carry this effect must depend upon the capacity for diffusion of the currents employed. Probably no current administered in therapeutics so universally pervades the tissues of the body as the static wave-current

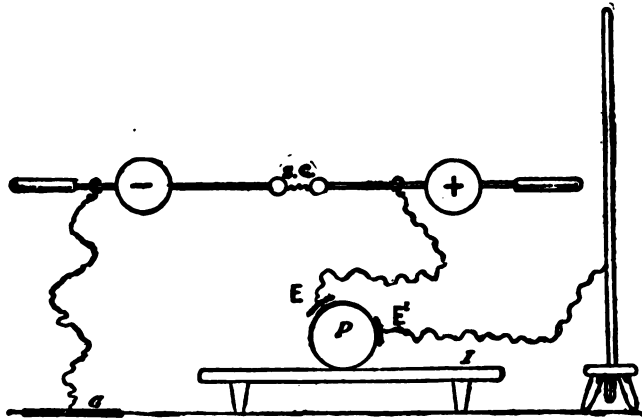


FIG. 2. Showing Arrangement with an Insulated Capacity.

I, Insulated Platform; P, Patient; E, Electrode; E', Second Electrode;
G, Ground Connection; S. G., Spark Gap.

administered by means of an electrode applied to a small area. It must immediately pass through the body in every direction and surround the whole surface of the patient, passing in nearly straight lines. In its passage it produces universally effects, whatever they may be, peculiar to electricity, upon the tissues. The most intense effect of the current, however, upon protoplasm

must be in the tissues immediately beneath the electrode.

The action of a current of one polarity in passing through the tissues produces effects which differ from the other currents, which alternate between the two opposite polarities. During the to-and-fro passage of the wave-current all cells are like charged. While it is difficult to reconcile the idea of the separation of cells in tissues which are relatively homogeneous, still there is reason to believe that the cells, on account of this condition, are temporarily polarized, assuming different shapes and acting in ways which arouse activities capable of producing various alterative effects upon the tissues which they compose.

The constitutional effects of the static wave-current are pronounced, and from the study of a large number of clinical results, it has been demonstrated beyond question to be of great utility in the treatment of many conditions. The action will be best understood from the foregoing description of the *modus operandi* of the vibratory and other effects of the current as described. Undoubtedly these constitutional effects are largely due to the mechanical influences of the discharges and peculiar actions of electricity as described.

The evidences of an increase of general metabolism are marked by the restoration of normal functions, notably the activity of the secretions, followed by increased appetite and gain in weight and muscular strength, when properly associated with exercise during courses of treatment. The increased *elimination* of solids in the urine in

excess of tissue combustion is demonstrated in patients who have been inactive, and in whom the general nutritive functions are sluggish. With these cases it is the general rule that during the first weeks of treatment the percentage of solids in the urine is much greater than after the effects of poor metabolism have been eliminated. After some time this high percentage gradually falls off, but still a larger per cent. will persist than that present prior to the institution of the regular administration of the current. This is due to the fact that the general activities which have been restored produce an increased oxidation of tissue, coincident to normal healthy metabolism.

Of arterial tension there will be, as indicated above, an increase locally during an administration, but the effect upon the general system, if the administration is prolonged, is to lower the arterial tension, noticeable in the changed character of the pulse. Coincident with this condition will be a lessened frequency and fuller rhythm of the heart's action and the normal associated changes in respiration.

Upon the nervous system the static wave-current produces changes in condition coincident with the altered nutrition and changes of circulation, as well as markedly diminished nervous irritability, and associated high tension, which is noticeable in the relief of muscular spasm and, to a marked degree, of nervous tension.

Heat production due to a greater degree of tissue oxidation coincident to general increase of metabolism is one of the remarkable effects of this modality, and one of the strongest evidences of its positive action upon a human

organism. In order to demonstrate this fact, which the writer had always observed to be pronounced when administering the current to patients for periods of twenty minutes to one-half hour, he made the following experiment: A patient was placed upon the static platform in a room having a temperature of 30° F. When the patient seated herself she was feeling chilled and her feet were cold. A large metal electrode was placed over the liver and solar plexus and the wave-current was administered in the usual manner, employing a spark-gap of four or five inches; at the end of ten minutes, the patient was feeling no discomfort, and at the end of twenty minutes was thoroughly warmed and comfortable. This experiment practically demonstrated the energetic effects of this current upon tissue metabolism and heat production.

Upon the secretions, the action of the wave-current is very pronounced. During the first administrations, when instituting a series of treatments of a patient having general sluggishness of the functions of the skin, there may be little or no secretion of perspiration during the first few treatments. There will, however, be a marked increase of the perspiration and other secretions in most such cases after several administrations. The evidence of the increased secretion of other glands, which as a rule resume coincidentally with return of the secretion of perspiration, is demonstrated by the better performance of the functions upon which they depend.

It is easily shown with a patient whose digestion is impaired by giving a test breakfast, and two hours after

the meal taking the contents of the stomach for examination. On the following day give another test meal and at the expiration of one-half hour apply a flat metal electrode over the epigastrium, and administer the wave-current at this site for fifteen or twenty minutes. Two hours after taking the meal withdraw it for examination and compare them. Whereas the second meal will be well digested, the first will be found to be not nearly so completely digested unless the patient's digestion is normal. It is also observed with patients in whom the secretion of the liver has been pronouncedly deficient, that when the wave-current is applied over the organ, within a few days there will be marked evidence of an increased functional activity. The same is true of the kidneys, pancreas, and intestinal secretions. These results demonstrate the great utility of this current upon conditions in which the functions are inactive.

There are no evidences of fatigue or over-stimulation of the organic structures when administrations are given in normal individuals for from twenty to thirty minutes, but, on the contrary, increased functional activity, and in congested conditions a degree of inhibition is induced which deserves consideration from all earnest observers. A very prolonged administration, over forty minutes, may however produce a feeling of fatigue, which is always followed after a brief rest by a sense of well-being. No effect is produced that can be considered injurious even after very prolonged administrations.

A wide range of therapeutic indications for the use of the wave-current is suggested by an increasing evidence

of its worth, and probably no one therapeutic agent to-day occupies a field of usefulness so large, especially in conditions of local congestion and in its beneficial effects upon local and general metabolism. It has been frequently suggested to the writer that in his previous work on "Electro-Static Modes of Application and Therapeutics" he has not been sufficiently full in the explanation of this valuable modality, which is the apology for devoting so much space to its application here.

The indications for its employment in therapeutics, as suggested from the foregoing, are as follows: (1) the relief of local congestion and hyperæmia, and the elimination of inflammatory exudates; (2) the relief of pain, which is usually coincident with the effect upon the preceding conditions; (3) to relieve muscular spasm; (4) to lessen nervous irritability; (5) to correct errors of metabolism; (6) to generally increase functional activity, (a) by its action upon the secretory and excretory functions, (b) by the restoration of local muscular tone, thereby relieving atony, (c) by overcoming nervous and muscular inertia.

Upon congestion and local hyperæmia, as present either with acute processes or conditions of functional inactivity associated with sluggish metabolism, the effect is most pronounced. Probably muscular and tissue contraction and the induced activity of cell protoplasm excited by the action of this current by overcoming stasis, are especially effective in relieving congested and hyperæmic conditions. It induces with the recurrent contractions and relaxations an expression of the fluids and increased

activity, with the re-establishment of circulation in the tissues coincident with an increase locally of the metabolic functions of elimination and repair. The best results are obtained in these conditions by the employment of low rates of frequency. Probably frequencies of one hundred and fifty to three hundred are the limit at which the oscillations should be permitted for the best therapeutic results in the treatment of inflammatory processes. It is appreciated by all who are familiar with the *modus operandi* of this current, in the conditions under consideration, that periods of rest between the intervals of contraction are essential to the attainment of the best results.

When we appreciate that congestions and hyperæmic conditions, associated with pressure upon the venous circulation,—acute and subacute congestions,—are the most common concomitants or causes of diseased conditions, we must admit the indications for the employment of currents of moderate frequency producing the mechanical effects of vibration and recurrent contractions. It is a draining process, the recurrent *vis-a-tergo* exciting activities that are invaluable in the treatment of inflammatory conditions. When the fact is realized that few diseases with pain, muscular spasm, functional neurosis, or other pathological conditions are not induced by inflammatory processes, the importance of the recognition of currents such as the wave-current and other modalities which induce resumption of circulatory drainage and repair, must be appreciated. A local lesion should be suspected and its character considered in all painful and functional de-

rangements, for in most instances the conditions may be referred to a coexisting inflammation. It matters not with the employment of the wave-current whether the congestion or hyperemia is located beneath superficial muscular structures, as in sciatic neuritis, or in the deeper viscus or great glands of the body, under proper treatment. The amplitude of the oscillations of this current, when induced by a machine of proper capacity, is sufficient to penetrate remote parts and influence the denser, deeper tissues of the human organism except in very obese subjects. The author's familiarity with the work of many who have employed this modality with different measures of success, induces him to urge a more energetic and intelligent employment of the wave-current; for those who have not succeeded as they should, have employed it in an inefficient manner. The following rules of dosage, if carefully followed, are a sufficient guide for its successful administration.

I. *When employing the current for the relief of acute local congestion*, over the inflammatory area at the beginning of the first application, with but a short spark-gap, severe pain will be produced, which is caused by the contraction of the muscular structures including the muscular coats of the arterioles in the inflammatory area, producing pain by pressure. In a few moments, however, as the fluids are expelled, a longer spark-gap can be administered with not greater discomfort than was at first experienced. In this way, by gradually lengthening the spark-gap, and thereby increasing the amplitude and deeper penetration of the current, the more remote tis-

sues are reached, and the entire congested region more or less completely drained and the tissues left in a state of tonic contraction. The length of spark allowed to pass at the spark-gap during an administration will depend therefore largely upon the degree of discomfort produced at the time of the application and should be lengthened as the patient, tolerating a moderate degree of pain, permits it.

II. *In the treatment of deep-seated conditions*, where the congestion is not sufficiently intense to cause pain in connection with the administration of the current; and in *atonic conditions*, the guide as to dosage will be the degree of muscular contraction produced; avoiding the induction of an unpleasant or tetanic muscular contraction, but crowding it up to the limit at which this effect will begin to be produced.

It must also be remembered that an electrode large enough to cover considerable surface relatively diffuses the current, so that, when it is desired to get an intense local vibratory effect upon some lazy viscus, it will be necessary to make the electrode small enough that the maximum spark-gap to be obtained will produce an intense local effect. Many in the past have been negligent in giving the proper amplitude and intensity with the administration because of the noise of the discharge at the spark-gap or want of a proper appreciation of the requirements. The unfortunate disadvantage of the noise may be overcome by a properly constructed muffler, which will relieve this unsatisfactory feature of the administration (see Fig. 3). In the writer's experience,

however, nervous patients tolerate the noise much better than some physicians who treat them.

These observations on dosage apply not only to the administrations to inflammatory conditions, but to the applications of the current in all cases. It should be farther



FIG. 3. Glass Muffler.

added that the wave-current cannot be used entirely to the exclusion of the more rigorous static modality,—sparks. In some cases, as of deep-seated congestion and conditions associated with the presence of inflammatory exudates and when it is desirable to get a prompt response of the perspiratory function, the application of sparks and the superficial action of friction sparks will afford an additional benefit to the condition.

Attention must be called to the fact that there are certain inflammatory processes and conditions due to or associated with the presence of germs in which these static modalities will fail and are also contra-indicated, that is, in the treatment of local septic processes where pus is present, or where some other germ process is present beneath the integument. In such cases no static modality has proved efficacious. When pus is walled off

by surrounding induration, stasis is a protection against the extension of infection and must not be disturbed by the wave-current or any influence which will remove the *wall of safety*.

In syphilitic processes, gonorrheal rheumatism, tubercular processes, and infectious disease this modality fails, but will be found a valuable aid to diagnosis by exclusion in tubercular arthritis and gonorrheal rheumatism. If success follows the administration, such processes may be eliminated, as has been the writer's experience with tubercular joint affections. In all other than infected conditions positively beneficial effects are certain to result.

Pain is probably relieved by this and the other high-potential modalities which produce perceptible muscular contraction as by no other agent except morphine, because the presence and pressure of local congestion are relieved. In these cases, the relief is associated with a curative process due to the removal of inflammation; first, by overcoming local stasis, and, second, by the removal of inflammatory exudates, while with anodynes the relief is but temporary and never curative. The writer's observation in the treatment of painful neuroses has led him to believe that many of the pains of so-called "neuralgia" are not reflex but associated with remote inflammatory conditions. Pains, however, due to low grades of toxæmia arising from improper evacuation of the alimentary tract, imperfect metabolism, or malarial poisoning, cannot be strictly referred to inflammatory conditions. Such pains, however, are remarkably re-

lieved by overcoming the conditions which caused them; for the relief of which, except malarial cases, probably no agent will contribute more than the static wave-current.

Muscular spasms or contractions of the skeletal muscles are certain to occur in connection with inflammatory conditions of the joints, disappearing upon removal of the causative conditions. Contractions, however, of cerebral origin, such as those of *athetosis*, do not respond to treatment. Many of the contractures associated with the functional neuroses, as of the uterus in cases of dysmenorrhea, respond very promptly to the administration of the wave-current, vacuum tubes, or static sparks.

In conditions of nervous irritability the origin of the trouble is found usually to be an inflammation located somewhere in the organism. It is therefore necessary to carefully diagnose the original condition and then make the appropriate administration. If this is done in a thoroughly systematic manner, there will be little difficulty in relieving most of the functional and many organic nervous conditions.

General errors in metabolism whenever present, either local or not, unless some organic condition precludes the possibility of restoring the normal condition, may be greatly relieved by these modalities. It may be wise, however, to combine with it in many cases the administrations of dry heat, light, or mechanical vibration. If, however, but one method of treatment were to be used in the treatment of sluggish conditions, there is no modality that offers so much for their relief as the static wave-current. For the treatment of these affections, the ad-

ministration should always be made over the organs which are the seat of the difficulty, or in doubtful cases it may be applied with comparative uniformity over the abdomen, employing an electrode about five by eight inches in size, placing it over the anterior portion of the liver, the epigastrium, solar plexus, and pyloric end of the stomach and pancreas, with a view to effecting an active metabolism and improving the nutritive functions.

Activity of special functions may be gradually accelerated by this energetic modality, bearing in mind that wherever muscular structures are present in glands, arteries, and other structures, the effect of inducing muscular and other tissue contraction, causing an expulsion of fluids locally, and coincidentally increasing the general activity of the functions of the body, especially of those organs immediately beneath the electrode. Under this heading will be included an increase of secretion and excretion, restoration of normal blood circulation, relief of muscular atony, and the restoration of tone to the structures of the body.

Conditions of nervous inertia or general inactivity of function, so common in persons who lead sedentary lives without sufficient muscular exercise, will be generally overcome and their lives lengthened. These observations, which have been demonstrated by the therapeutic results in the treatment of hundreds of cases in the clinics and practice of the writer, are sufficient to warrant the general adoption of the wave-current and other high-potential modalities, especially those which produce a well-marked degree of perceptible tissue contraction.

CHAPTER III

THE STATIC INDUCED CURRENT

THIS current, the oldest of the high-frequency currents, was discovered by Dr. Wm. J. Morton of New York. It is described by the author as follows:

“From the earliest medical electrifications by the Abbé Nollet in 1734—we become familiar with the breeze, spray, sparks, and shock, but no mention is made of a current disassociated from the spark delivered to the person, nor prior to my own had any electrodes been shown by which a current, except in spark form, could be delivered from a Holtz or any other influence machine. When, in general, nerve and muscle reactions were spoken and written of, reference was had to galvanic and to faradic currents from coils and voltaic cells, or from coils and magnets, but not to any current derivable from frictional electricity. The spark and static electricity had become synonymous terms. That no one during one hundred and fifty years should have sought out the kinetic or current feature of the static discharge (in other than spark form) and harnessed it to an electrode capable of bringing it into use, seems most remarkable. . . .

“My new system, published and unpublished, comprises the development by an influence machine of a rapidly interrupted and graduated current, by means of a circuit-breaker, introduced into a circuit with and with-

out condensers, and in the medical applications of this current without and within the human body by moistened sponge or other electrodes, just as in the case of the ordinary galvanic and faradic currents.

“ It involves the removal of the spark, in itself more or less disagreeable and painful and often difficult to localize, especially about the face and neck, away from the patient's body, and yet retaining all the physiological effects of the kinetic or current part of the circuit. The spark is no longer a direct feature of the administration; it occurs at some distant part of the necessarily closed circuit, and in modified form now becomes mainly a regulator for timing the discharge of the equalizing potentials.

“ The circuit-breaker is a pair of adjustable metallic ball electrodes, introduced at any point of the circuit, having a narrow air space between the balls; the circuit makes when a small spark overcomes the resistance of the air, and breaks when it fails to do so, and the current is due to rapidly successive equalizations of the differences of potential of opposite charged condensers, with either the prime conductors or the addition of Leyden jars. . . .

“ Accepting the fact that the rapidity of succession of impulses of the new current is in itself sufficient to produce a steady circuit, we may now go a step further and say that each impulse in itself consists of a vast number and range of oscillations or alternations (of one hundred millions per second), and, putting all the facts together, we may doubtless willingly concede that a current must

possess equally positive and differing physiological properties." . . .

" In his earliest publication upon this subject appear the following for physical results then noted. The event has shown that many of these were then imperfectly understood and appreciated, but the question before us is whether or not these observed results were in fact novel."

1. " By means of the spark-gap at the discharging rod, the imperceptible physical effects ' may be regulated to a nicety, ' " from an almost imperceptible tingle up to the extreme rigid flexion of the arms.

2. " The effect is soft and agreeable and accompanied by no shock," while the inner coating of the jars gives a series of discharges which, even when slight, are " too painful to be borne."

3. " Capable of causing physiological tetanus," while a connection between the inner coating of the jars " in silent current forms produces no muscular contractions or sensations of any kind."

4. " When compared with the galvano—or magneto—induced current, both produce more efficient contractions and give less pain to the patient, when pain would be produced by any of the three."

5. " Renders a static machine capable of producing all the effects of faradism, doing ' all the work of the best faradic machines ' in addition to the ordinary static effects. ' In its general characteristics ' this current ' cannot be distinguished from the ordinary faradic current.' " *

* Extract from Report of the Committee on the Static Currents of the American Electro-Therapeutic Association.

The acknowledgment of Morton's priority in the discovery of this current has been recognized by all recent writers upon the subject of high-frequency currents, including Tripier, Bourgoni, Leduc, Paschles, Ranney, Williams, Weil, Bordier, Freund, Jenks, Thompson, Herdman, and others.

The footnote from Freund * explains itself.

The following description of the method of employing the current and its physics by the Committee on Current Classification and Nomenclature was published in the *Journal of Advanced Therapeutics* for January, 1904:

"The patient is directly in circuit with the outside coatings of two Leyden jar condensers in series. The spark-gap and machines are in multiple with each other. With the patient included in circuit in the manner shown in the diagram we do not know the value of the inductance and resistance offered by him. The arrangement of two condensers of small capacity is conducive to the production of oscillatory currents of relatively high frequency, and such currents will be produced if the patient offers a

* Extract from "Radio-Therapy," Freund: "In the year 1881 Morton described a method of using electricity for the local treatment of muscle and nerve disorders. He brought the terminals of the discharger of an electrical machine so near together that sparks passed between them. He then put his patient in the circuit connecting the tin-foils of the condensers. Morton was the first to produce by means of this arrangement and to therapeutically apply high-frequency currents, for he had used the oscillating character of the condenser-discharge to increase the frequency of an alternating current. The condensers were charged in this case through an induction apparatus. Morton's high-tension oscillating currents have been used by Leduc and F. Winkler in similar affections, and, of course, with results similar to those produced by other forms of high-frequency apparatus."

sufficiently low resistance and inductance. In the July, 1903, issue of *Medical Electrology and Radiology*, Dr. Manders expressed the opinion that the impedance (sum of the resistance and inductance) of the circuit including the patient may be so great as to render the current unidirectional by damping out the oscillations which the condensers of small capacity tend to produce."

"The term 'static-induced' applied by Dr. W. J. Morton to this arrangement, made by him in 1881, is techni-

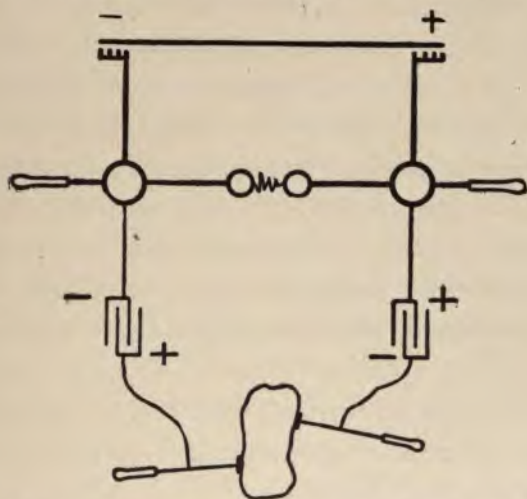


FIG. 4. Arrangement for the Static Induced Current.

cally accurate (Report of this Committee, see *Journal of Advanced Therapeutics*, Vol. XXII, Jan., 1904, p. 29). This term expresses the arrangement by which, as is now generally understood and conceded, currents of the character technically known as high-frequency currents were first produced, and applied to therapeutic purposes in such a way as to be tolerable to the patient; and on the

basis of which arrangement some subsequent arrangements are founded; for example, that of d'Arsonval, also those more recently devised by Dr. Morton."

The physiological actions of the static induced current include the actions described by Dr. Morton in his description of the current as given above. A wider conception of the effects of the current characteristic of the action of the high-potential discharges in the production of tissue contraction, however, widely enlarges the scope of its application. In this respect it is analogous to the local actions of the wave-current as given in the preceding chapter. An alternating current employing two metal electrodes, however, produces chiefly local effects—the electrical and mechanical effects upon the tissues beneath the electrodes and in the interpolar region between the two surfaces covered. The local actions, however, of this current are to effect in the same manner the relief of local stasis and sluggish metabolism as those of the wave-current.

The static induced current, however, possesses certain advantages over the wave-current which will arise in the experience of every practitioner.

During periods of humidity, when it is impossible to administer a spark-gap of sufficient length to produce the indicated local vibratory effect beneath an electrode, necessary to overcome local congestion with the wave-current, the static induced current having a more limited and localized field of action, and the added intensity of the characteristic condenser discharges, produce with a shorter spark-gap a much more profound local effect.

It is necessary, when employing this current, to make the applications to two different parts of the body. One may be placed over some part as an indifferent electrode, or may be valuable in the treatment of two parts, as both knees, in a very stout patient. In such a case an intense local effect will be demanded.

The application of two electrodes may also be of particular value in the treatment of a local inflammatory condition in one part and at the same time an additional application over some other part of the body where the functions are particularly sluggish, as over the liver or intestinal tract.

The static induced current may be used with two glass vacuum electrodes applied over two different parts of the same patient or to two patients at the same time, or with the vacuum tube at one part of the body and a metal electrode on another part. This plan of treatment will be found very convenient in the treatment of certain pelvic conditions where it is desirable to employ the metal electrode over the abdomen and the glass tube internally. (See Plate I, Frontispiece.)

Whenever two electrodes are applied at different parts of the body the local effect may be disagreeably unpleasant over one surface to produce sufficiently energetic effects over another. This may be easily regulated either by regulating the size of the metal electrode or by placing a larger-sized Leyden jar in connection with the machine on the side where a more energetic action is indicated. By this means, with the three usual sizes of Leyden jars that are provided with the static machine, it is possible to

make very fine adjustments of the effects of the current in connection with each electrode. (See Plate I.)

It must be borne in mind that the static induced current, as indicated above, does not produce the constitutional effect upon the organism that is produced by the wave-current. It is not therefore indicated, except when necessary on account of atmospheric humidity, in cases for which there is no special indication for the improvement of constitutional conditions, or when time may be saved by treating two parts requiring an application of too great intensity to be treated at one time with the wave-current.

CHAPTER IV

DISRUPTIVE DISCHARGES, SPARKS

THE high-potential spark discharged either with or without the intervention of a resonator in connection with a coil or static machine, is one of the most valuable of the modalities employed in therapeutics; from the entire surface of a patient to the point of discharge the currents focus and escape, forming a vortex, as it were, leaving the tissues behind in a state of perturbation. Of this method of administration, but two modes, the usual ones, deserve consideration,—*the indirect spark and the resonator spark.*

The indirect spark is derived only from the static machine and may be described as follows: The patient is seated upon the platform, which is connected usually by a shepherd's crook from a metal plate placed upon the platform beneath the chair to the positive side of the machine (the negative connection is preferred by some operators). The opposite side should be grounded by means of a metallic connection with moist earth. (See Fig. 5.) The operating ball is connected from the screw eye of the metallic portion with another chain or other metallic connection also to the earth. With this provision it is not necessary that the operator be insulated from the metal connection, as no effect is produced upon him when administering the spark if the connection to the earth is

direct, as no appreciable part of the current will leave the better conductor to the earth for a poor one, as the operator standing upon the floor. It is customary therefore for the operator to hold the chain in his hand against the handle of the ball and at the same time, with the other

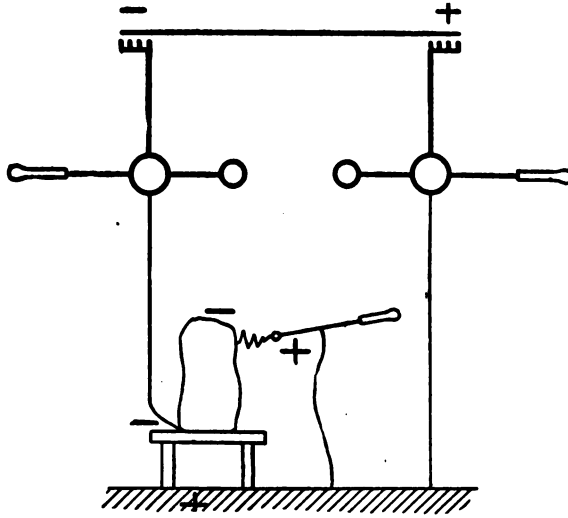


FIG. 5. Arrangement for Indirect Spark.

hand, hold it in such a manner that it will not be constantly thrown to and fro against the platform or the patient, interfering with the administration. The sparks may be administered of any desired length according to the indications—the longer spark for the deeper perturbatory effect upon the tissues. To regulate the length of the spark either move the shepherd's crook to the rear end of the platform, remove the metal plate which acts as a condenser, slow the speed of the machine, thereby diminishing the output, or close the discharging rods so that the

balls are separated to a distance a little greater than the length of the spark desired. By these means we will determine the *potential of delivery*, or the length of spark possible to administer, which should always be regulated to the depth of tissue which it is desirable to affect. The length of spark should vary usually from one-half inch for application to the fingers to four or five inches over the glutei and back of the patient, according to the depth of the tissue, taking into account also the amount of adipose overlying the muscular structures, the latter acting as a resistance and at the same time breaking up the vibratory effect and the influence of contraction upon the structures affected.

A method of localizing sparks to the exact point where the operator would have them discharged, even in the cavities of the body, may be accomplished in the following manner:

Take in the left hand the wooden stick with the small insulated tip, the combination used with the glass sleeve for administering the brush-discharge, and with the large ball electrode held with the chain in the right hand apply the indirect sparks to the small ball at the tip of the brush-discharge electrode. This small bit of metal will attract the spark and thereby localize it over the point desired. By applying the spark to the metal portion where it enters the wooden stick, a spark may be administered in a cleft or it may be directed to a specially provided attachment having a ball upon one side where the tip is attached to the wooden portion of the electrode. The spark may thus be administered to a cavity by applying the spark

to the ball on the upper end of the attachment. In this manner the effects of the sparks will be appreciable, and therapeutically the result will be the same as if the spark were applied directly to the surface of the body; for from the spot where the small ball is in contact will escape the electrical discharge, the same as if the spark were applied directly to the surface. The method of making this application, as illustrated in Plate II, will render possible the administration of sparks or rather their effects to the interior of the body as well as in the clefts and hollows.

The resonator spark—the spark delivered from some type of resonator, or a solenoid in connection with a resonator—has a distinctly different quality from the indirect spark from a static machine. The warmth or sensation of heat varies with the amperage of the current that is passed into the resonator other things being equal. Many types of resonators have been constructed for use in connection with coils and static machines. The main features of a resonator are shown in Fig. 6. The high-potential source may be either a coil or a static machine. The current derived from the source of high-potential electrical energy passes immediately into the condensers of opposite polarity, which may be Leyden jars or metal plates, insulated from each other. The spark-gap between the two condensers regulates the amplitude and frequency of the discharges as they pass to a second coil, usually of the Tesla type, in which the primary and secondary currents are completely insulated from each other, either by oil immersion or some other intervening insulating material as glass or mica. In the Tesla type

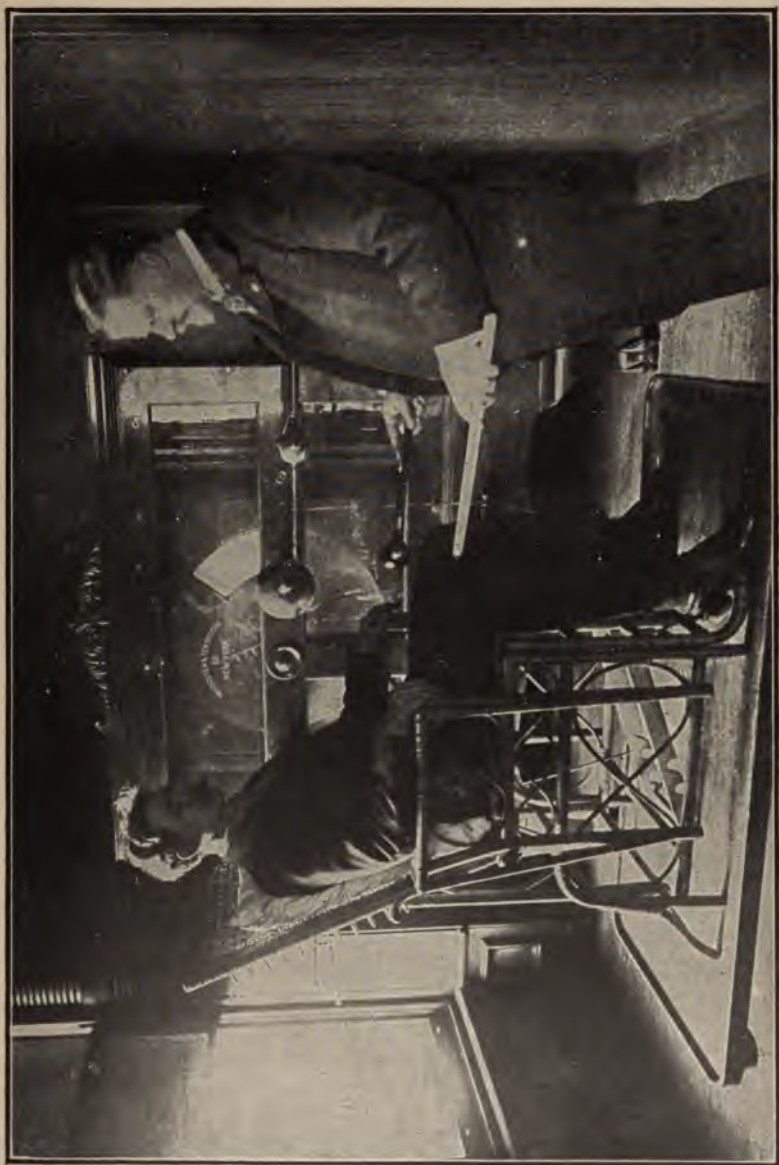


PLATE II. Author's Method of Localizing Sparks.

of coil there is no communication through an interrupter as in the types of Ruhmkorff or induced-current ap-

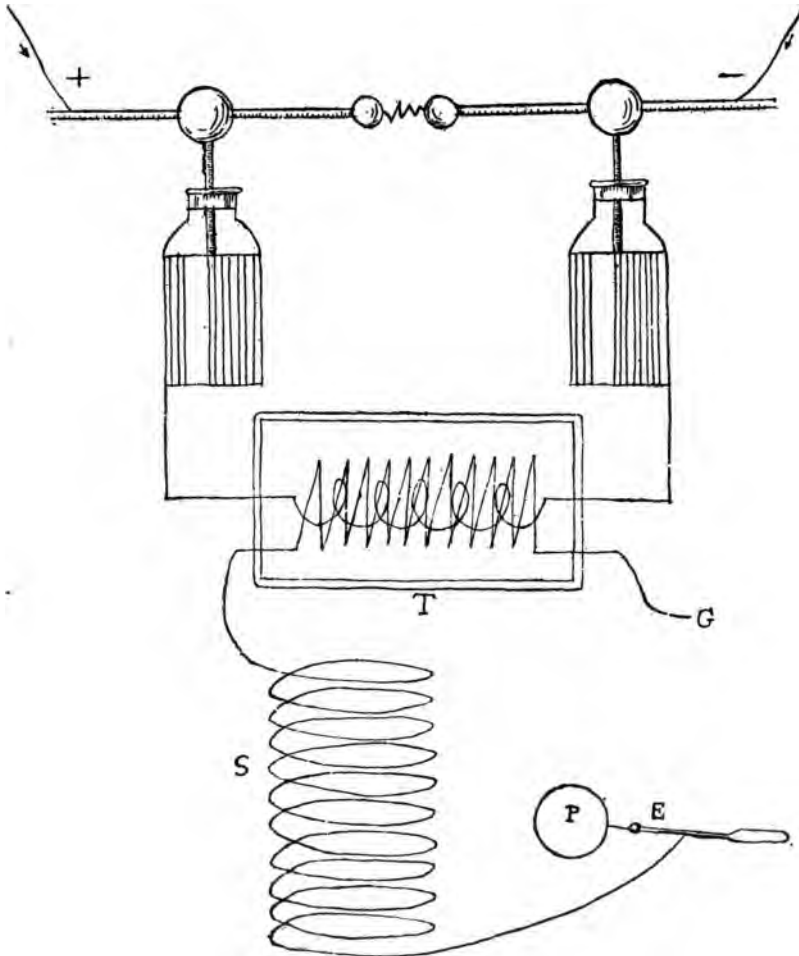


FIG. 6. Arrangement of Common Resonator.

T, Tesla Coil. S, Solenoid. P, Patient. E, Electrode. G, Ground or Earth.

paratus. (See Figs. 7, 8 and Plate III.) The current that is used therapeutically is taken from the secondary coil.

The frequency of this apparatus consists of multitudes of oscillations which are discharged from the terminal, but in association with the impulses synchronous with the spark-discharge between the discharging rods of the resonator. With this pulsatory discharge of the multiple frequencies there is always one or a group of discharges of a spark length somewhat longer than the distance be-

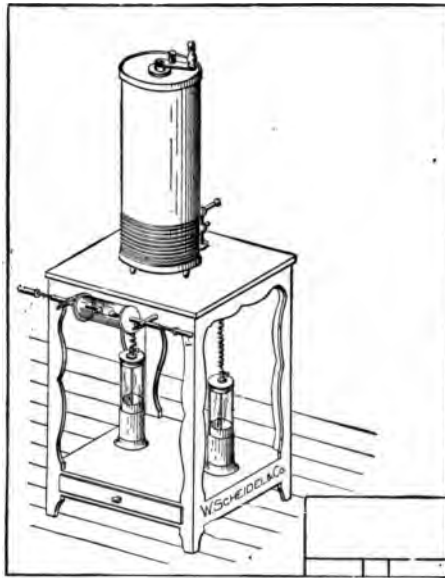


FIG. 7. Scheidel Resonator.

tween the balls of the resonator. These are more energetic and of a lighter color than the numerous oscillations which accompany it, and are the only ones to be considered of therapeutic value. It cannot be looked upon as a high-frequency discharge, but a discharge of a potential of delivery equal to the spark discharged between the balls



PLATE III. Showing Static Resonator and Method of Administering Resonator Sparks.

of the condenser, plus the potential added by the inductance and impedance of the circuit of the Tesla apparatus alone or combined with a solenoid. (See Plate III.) This *potential of delivery*, or spark length, will measure the extent of the perturbatory effect of the spark upon the deeper tissues. These sparks produce a less sharp sen-

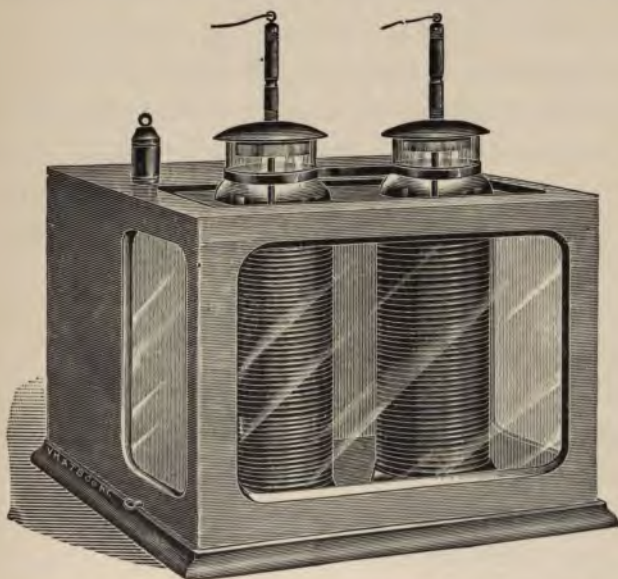


FIG. 8. Morton High-frequency Apparatus.

sation than the indirect spark of the static machine, but have a more stimulating effect upon the tissues superficially. It is indicated, however, when superficial applications are required and not the deep perturbatory effect of the long indirect spark, which action depends for its intensity and depth of effect upon the length of the spark discharge and character of the grounding. The resona-

tor spark when derived from a coil apparatus possesses more therapeutic value than any of the other discharges derived from such apparatus, for the treatment of inflammatory conditions, producing as it does distinct muscular and tissue contraction, relieving local congestion and also inducing local hyperemia in the superficial tissues. It is the choice for the treatment of such conditions not too deeply seated if the time required for the administration is to be considered, but no more efficient than the discharge from the resonator of a static machine except that a longer time is devoted to the application. This modality is of great value in the treatment of superficial inflammatory conditions as inflammation of the smaller joints, for commencing abscess, or acne pustule; as well as having a remarkable field of application in a great number of skin diseases including the obstinate port-wine marks, eczema, lupus vulgaris, lupus erythematosus, psoriasis, herpes, sycosis, and a multitude of other conditions where antiseptic and tonic effects are indicated, and for restoring tissues to a normal condition of metabolism, thereby eliminating abnormal processes. There are various types of this form of apparatus on the market, some of which are shown.

The further consideration of the therapeutics of these modalities is referred to frequently in connection with the treatment of various conditions elsewhere.

CHAPTER V

THE CONVECTIVE DISCHARGES OR EFFLEUVE

THE electrical discharges that are given off from metal points or from a relatively non-conducting material, as a wooden stick, either from a point or convex surface without the passage of a spark or disruptive discharge, are known as *convective discharges*, or the *effleuve* of the French.

These discharges are of a warm or hot burning character in proportion to the amperage of the current that is passing or the proximity to which the electrode is held from the surface of the body. *The direct coil effleuve* is consequently relatively hot, and unless held at considerable distance will generally produce, in a very short time, distinctly cauterant effects.

The static discharges of this character have been designated as the *spray* or *brush discharge*. The former is administered from a metal point, and the latter either from a metal or wooden terminal is passed through or over a wooden electrode. The latter material, offering a distinct resistance, prevents the current passing in a smooth discharge except when discharged from a point, when, other things being equal, it is much the same, but less irritating than the discharge from a metal point.

The spray is the oldest form of convective discharge and has been used by many operators in the past, both

from single and multiple point electrodes. (See Figs. 9 and 10.) Its characteristics, however, for the relief of inflammatory conditions, in which affections these dis-



FIG. 9. Single Point Electrode.

charges are usually employed, is not as effective as those of the brush-discharge, which is therefore the elected means of employing the convective methods of treatment from a static machine. This method may also be administered from a low-frequency coil resonator.



FIG. 10. Multiple-point Wire Brush Electrode for Administering Spray.

The brush-discharge (a therapeutic expression in technical variance with physics), administered preferably from a green, unseasoned wooden electrode about 3-4 inches in diameter (see Fig. 11), serves a valuable purpose in therapeutics. The discharge has a distinctly disruptive characteristic, as if multitudes of little sparks were passing in rapid succession, producing a feeling when projected against the surface as if sharp particles of sand were thrown against the skin. This characteris-

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tic led Dr. Humphries to designate it * as a *disrupto-convective* discharge, which practically explains the character of its action. To this disruptive feature or impulsive character of the discharge is largely due its greater



FIG. 11. Author's Set of Brush-Discharge Electrodes.
1, 2, and 3, Wooden Terminals; 4, 5, 6, 7, and 8, Insulated Metal Terminals.

degree of beneficial action in the treatment of superficial inflammatory conditions, to which it is so well adapted.

This modality is administered uniformly with the patient seated upon the insulated platform. The discharging rods should be widely separated and the patient hold the shepherd's crook in the hands or having the feet bare upon a metal plate, connected with the negative side of the machine, and the positive side should be grounded. It is demonstrated and a well-recognized fact that when the patient is connected to the positive side, the effect is distinctly irritating, as well as aggravating to inflammatory conditions. The object in having the patient brought thus in direct connection with the machine is that the current may not be diffused too much over the platform and other part of the insulated portion of the apparatus be-

* See Dr. Humphries' Chart of Static Modalities, published by the Hospital Supply Co. New York.

fore passing to the patient, thereby permitting a much more energetic administration with a lower rate of speed, which latter may be varied to the demands of the case. If the wooden electrode does not permit a discharge of two or three inches between the surface of the patient and the end of the electrode, which is desirable for most administrations, the speed of the machine may be accelerated or the surface of the electrode may be dampened from time to time with a wet cloth held for the purpose in the hands of the operator. By the employment of moisture in this manner it is possible to apply these discharges from an old seasoned stick, but the discharge is never as smooth and satisfactory as when administered from an unseasoned stick. The wood of which these electrodes are made should be of some uniform texture not having a coarse grain, such as cottonwood, whitewood, basswood, or what is still better, the white portion of the sugar maple. The maple sticks do not dry out or season so rapidly as the whitewood or other soft woods.

When administering the current the operator should hold the sliding metal collar provided with the screw eye for attachment of the hook of the grounding chain upon the surface of the electrode, so that it reaches just beyond the finger, otherwise the discharges will produce a disagreeable, burning sensation to the hand. In lieu of a properly made collar, a few windings of a strip of soft metal upon the end of the stick, with the grounding chain passing to the metal, will answer the same purpose. The operating chain may or may not be connected to the earth, the current passing through the operator. This will de-

pend upon the intensity of the discharge that is required. If it is desirable to get a pronounced effect the current should be grounded, otherwise, as in making applications about the eye, or within the ear or fauces, the machine may be run slowly and the current grounded through the person of the operator to the floor of the room. In this event the operator should avoid contact with metal conductors or suffer unpleasant shocks.

A condition which may arise when the static machine is running rapidly and prove unpleasant to the patient, will result from the passage of sparks arcing across on the interior of the machine which will cause very disagreeable contractions at the wrist. Under these conditions, the machine should be run at a lower rate of speed, and, if necessary to get the desired effect, the outer surface of the electrode may be made more moist. An unpleasant circumstance which may occur with the uninitiated, will arise from the passage of a spark between the balls of the discharging rods, which have not been widely separated. Another point to be observed is that when administering the brush-discharge the patient should sit directly opposite the pole to which he is connected,—the negative side;—otherwise the current will arc across, producing a burning sensation upon the surface of the patient nearest the positive prime conductor.

During the administration, the electrode in the hands of the operator should never be held in a fixed position, but should be moved about constantly over the surface to which he is making the application. This is done for two reasons:—(1) because the interrupted character of

the discharge administered in this way produces impulses of contraction in the underlying tissues, and (2) because the application from an electrode held in a fixed position is too severe to be borne by the patient. Under most conditions an electrode will after a time become carbonized through its length or certainly for a portion of the length, at the end nearest the patient. The discharge will then become similar to the spray given off from a metal point electrode. Under these conditions, the electrode should be thoroughly moistened over the extremity, when the discharge will again assume the *disrupto-convective* character producing the sense of hot sand thrown against the surface. The brush-discharge is one of the most valuable high-potential modalities, and the technique of application is not difficult if the above suggestions are followed literally.

The effleuve from a coil may be administered either from the coil direct or from a resonator. In the latter case the amperage is considerably diminished and the hot burning sensation much lessened. It may be administered from a metal point or carbon electrode, as the discharges of this character will not pass through the wooden electrode with sufficient efficiency to be of value. These discharges will vary in length and potency with the potential of the apparatus from which they are derived, and should be held at a distance at which the effect produced may be borne by the patient, when moved rapidly over the surface, the effect of which, as stated, is to produce a superficial hyperæmia. The effectiveness of these discharges in therapeutics, while valuable in pro-

ducing a condition of hyperæmia, is rather too severe for application to most inflammatory conditions, except those conditions where a local cauterant action is desirable, as in the destruction of a local septic process which is superficial in character. If the coil current is used for the relief of inflammatory conditions, it is much more desirable to use the sharp resonator spark, which has been described in the preceding chapter; or from a modern electrode having a metal collar connected with a low-frequency resonator discharge, a brush-discharge may be administered if the surface of an electrode of wood is kept thoroughly moistened.

The physiological action of the convective discharges is of considerable importance.

Rubefacience—the production of a distinct redness—occurs when the application is made to one surface for a considerable time, occasioned by the irritation of the superficial capillaries. The effect of the discharges is very distinctively antiseptic on account of the heat produced, and also owing to the action of ozone and nitrous acid and the intense vibration effects of the discharges of light frequencies upon organic germ life.

The action upon the tissues of the interrupted convective discharges over inflammatory conditions is to relieve local *stasis*, softening the underlying tissues, by removing the induration that is present and thereby restoring normal circulation to the parts and instituting an active local metabolism. This effect is also followed naturally by a resumption of tone in the arterioles beneath the skin, which is shown from the fact

that there is no disposition to relapse, which would otherwise occur. When these discharges are applied over oozing ulcerated surfaces, the surface becomes covered with coating or film, shiny in appearance—as if the surface had been brushed over with collodion. This is due to evaporation and the contraction of the superficial cells and forms a protection to the surface which will persist for a considerable time. When applied too intensely and for too long a time to a small surface, the discharges will produce a blister or an eschar, burning the tissue. These effects are produced most promptly by the larger ampere discharges from a coil effleuve. The only purpose that this effect will serve in therapeutics is the destruction of small areas, as warts, moles, or angiomata, and in cases in which there is a suspicion of local sepsis or the bite of a snake, or where an abraded surface has been exposed to septic infection.

Rubefacience. The general application of the discharges to the surface of the body, producing a dilatation of the superficial capillaries, will greatly relieve arterial tension and lessen the labor of the heart under various conditions, as those present in *arterio-sclerosis*. It also acts as a local counter irritant, relieving deep congestion under the general principles of the use of counter irritants. The indications for its use are in *arterio-sclerosis* as suggested, and over inflammatory conditions where, in addition to the effects, to be shown later, upon the deep congestion, the additional effects of counter irritation are produced.

The antiseptic action due to the cauterant oxidizing and chemical effects of nitrous acid and the intense vibrations of the violet discharges, though very superficial in their action, are sufficiently energetic to destroy certain types of infection, notably in superficial cases of lupus vulgaris and lupus erythematosus. The author has relieved a case of lupus vulgaris in six weeks and with no other application than that of the brush-discharge, which had been under treatment by various local applications for a year and a half. It must not be presumed that these convective discharges transmit the products of decomposition produced in a spark discharge or effleuve beneath the surface, or that it is possible to carry an ionizing influence beneath the integument. It must be also understood that the discharges are *from* the patient and not *towards* the patient as the appearance might lead the casual observer to suspect. Also, as stated above, these discharges are effective for the relief of local infection in the superficial layer of the skin when applied energetically enough to produce an almost cauterant effect upon the tissues, as over an infected, abraded surface, as suggested above. Another effect, which might be considered in a sense antiseptic, in that it admits the leucocytes and phagocytes to free access to an infection where an abscess will form, is explained in the following paragraph.

The effect upon local stasis of the convective discharges, when applied interruptedly passing the discharge to and fro, back and forth over the different parts of the surface where swelling and induration are present, is to generally soften the tissues. This is due

to the action of the discharges producing recurrent contractions of the tissues, thereby inducing an onward movement of the blood current through the vessels. Over superficial œdema as present in some cases of eczema and the swelling associated with bruises and sprains and where ecchymosis is present, the effect of these applications, systematically applied, is remarkable in its results. In conditions where local infection has set up an *abscess process*, as in felons (whitlows) and boils, the effect of the early application by overcoming local stasis and softening the tissues permits the blood to flow in freely through the area, enabling the leucocytes and phagocytes to destroy the infecting germs and restore the conditions to normal, where otherwise would supervene a painful abscess process. Nothing could be more gratifying than the results in these cases. The action upon local stasis is not only to relieve the conditions, but also to restore tone to the arterioles following the application, thereby preventing prompt relapse of the condition and furthering prompt and complete recovery. The application also undoubtedly stimulates end-organ metabolism and the elimination of effete materials, tending thereby to restore normal conditions in the shortest possible time.

The indications, then, for these applications are for the relief of all swollen and indurated conditions in which pus is not present in sufficient quantity to induce general infection by its escape into the general circulation, nature having provided induration for the walling off of a pus cavity. In cases, however, in which the in-

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fection is but slight the effect is, as suggested, to assist the leucocytes and phagocytes to relieve the system of the infection. It will require some careful discrimination on the part of the operator to determine the stage of the condition he has to deal with. As a rule, within the first two days of a felon or boil the relief of local stasis portends no harm to the patient from dissemination of the infection. In cases of tonsillitis, the result is most happy, if applied at the early stage, during the first day of the lesion, directly over the indurated spot, externally. The application should be continued until no induration remains, and repeated on the following day.

The range of application of these modalities also includes the superficial skin diseases, lupus vulgaris, lupus erythematosus, eczema, psoriasis, herpes, sycosis, favus, and numerous non-infected conditions associated with interference in the normal metabolism of the skin.

In acne, however, the application of the brush-discharge is not indicated, as the condition is not a local one, and it seems to cause a thickening of the skin without relieving the process when applied for a long time. In furunculosis it is also dangerous, as it is likely to drive the infection elsewhere, as it will if the application is made energetically to the surface. For these conditions, there are other means at hand,—light and the X-ray, which are as a rule effective.

To ulcerated surfaces the application of these modalities is one of the most valuable in therapeutics. Applied over the indurated margin, where it has a positive effect in removing stasis, it proves to be of the greatest

value for the relief of those conditions. The circulation is restored throughout the zone of induration which surrounds the ulcer, when a reparative process is immediately instituted.

For application within the cavities of the body the brush-discharge may be administered in connection with the glass sleeves that are shown in Fig. 12. These



FIG. 12. Glass Sleeves for Use with Brush-Discharge.

sleeves are slipped over the small prolongation tip (Fig. 13) which is placed in the end of the ordinary wooden stick electrode, and are designed for application to the



FIG. 13. Prolongation Tip for Use with Brush-Discharge.

cervix, in the fauces, and in the clefts as about the anus, where it is impossible to cause the discharge to pass directly from an electrode by other means. The sleeve may be moved to or fro on the end of the wooden stick, permitting a discharge of varying lengths to pass. The sleeve with tapered end is made for application to the ear, either for treatment of furuncles or for application to the drum or in otitis media, or the discharge may

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be thrown into the middle ear for treatment of the affections present in suppurative otitis media. In these conditions, success must depend upon the extent of the lesions present and upon the proximity to which the discharges may be brought to them and the dexterity of the operator.

CHAPTER VI

HIGH-POTENTIAL CURRENTS WITH VACUUM TUBES

VACUUM tubes employed in connection with high-potential currents were first constructed of the Geissler type, having a wire passed from without to the interior of the tube. A later type which serves the same purpose is the plain vacuum tube without any metallic connection with the interior. Both types of tubes are made in various forms suited to the treatment of special conditions, and also having various degrees of vacuum. They may be employed with any high-potential apparatus provided with an interrupter, and do not necessarily require that the discharges be of high frequency. The term so often employed of "high-frequency vacuum tubes" is therefore technically a misnomer. While it is necessary that there be interruptions somewhere in the circuit of a current of *high potential* to produce these effects, high frequency is not essential. The term which should be employed in therapeutics with reference to these tubes should therefore be *high-potential vacuum tubes* if referred to therapeutics, or *vacuum tubes for use in connection with high-potential currents*. The tendency for terms to creep into medical literature which are unauthorized and unscientific, and which call for corrections and establishment later of a different nomenclature, has led to much confusion in the past.

The phenomena of the high-potential discharges having various degrees of interruption in connection with vacuum tubes are unique. That the effect upon a hollow tube having an attenuation of gases in the interior is associated with peculiar electrical phenomena, whereas one containing the ordinary atmospheric air is void, has led to a study of electrons as excited under conditions which are peculiar to the different degrees of vacua of the various tubes. That the vacua of these tubes may also be so highly attenuated that no phenomena are produced leads to another conclusion—that these effects are not due to the action of the current upon the ether, but upon the gases in the ether under definite conditions of attenuation, showing that it is necessary to the phenomena that there be present within the tubes gases of proper densities.

When a tube of the requisite attenuation is brought in proximity to a high-potential source of electrical energy, even when a short air-gap intervenes, it is illuminated by the phenomena of the cathode rays giving evidence of the presence of negative electrons within the tube, demonstrating an affinity of cathodal high-potential electricity for the attenuated gases within these tubes.

The fact that the negative electrons of high-potential currents are attracted to certain degrees of atmospheric attenuation may explain some of the phenomena in the rarefied portions of the atmosphere.

The characteristics of these electrons are described by Sir Oliver Lodge in speaking of the cathode rays * as

* Archives of the Roentgen Ray for April, pages 185, 186.

follows: "It is from these rays (the cathode rays) that most of the others are derived. It is owing to a study of their nature that so much advance, almost of a revolutionary character, has been made recently in the science of electricity—advance which must have a perfect bearing. *The cathode rays* are flying electrical particles called electrons—actually particles—I cannot say particles of matter because *they appear to be particles of which matter is composed*, they are particles of electricity. We now know that electricity is really an atomic thing in the sense of having actual particles, and these particles are called electrons. They fly along in the cathode rays. Their motion constitutes all electrical currents. They go round in magnets and are in fact the substitute, the substratum of the whole electric science. When they are intercepted they give rise to radiation; when they revolve they also give rise to radiation. It is their acceleration which excites all radiation, and when they are suddenly stopped, as when impinging on a solid target, they give rise to X-rays. Wherever you have these flying electrons, these cathode rays, sometimes called *Beta rays*, where they constitute one variety of radiation from radium—wherever you have these rays striking and stopped suddenly—the X-rays take their origin." The positive ions are described by the same writer as "slow-moving ions of large size," or "heavy things which we are beginning to consider as quite a massive sort of thing,—they get to the cathode and in that way complete the circuit." It seems, therefore, that the important element in the effects of these vacuum tubes is the negative ion or cathode elec-

tron, and that the positive ions, while essentials to the presence of the inductive and electrical phenomena, are far less significant than the rapidly moving negative electrons.

There has been much argument and controversy as to whether electrons pass through the glass of the vacuum tube. Sir Oliver Lodge in the same paper affirms that the "negative electrons do pass through the glass." He says that, "these electrons in the cathode rays themselves may be emitted through the tube, too, and as a matter of fact, in addition to the X-rays, a certain number of Beta rays or cathode rays are emitted." "It is owing to the escape of these electrons that the vacuum has a tendency to go up gradually as the tube is used, and the tube thus has a tendency to become practically useless." Again he says that, "matter seems really to escape through the glass in the shape of atoms of electricity, for it cannot get through except in the forms of electrons. The constituents of the matter escape, and thus the matter itself escapes. If you hold an electroscope near the bulb, you will get the effects showing that these electrons are escaping."

He gives another explanation of the phenomena as follows: "It appears that some of the electrons pass through the glass, for if a proof-plane be held anywhere in its neighborhood negative electricity can be collected, provided the proof-plane is removed quickly enough, or the tube simultaneously stopped, so that its ionizing power shall not discharge the proof-plane."

It may be easily demonstrated that the phenomena pro-

duced either within a vacuum tube having no leading-in wire or a Geissler tube, are exactly the same when connected with a high-potential source of energy, indicating that the discharges which pass to the collar of the tube holder connecting the vacuum tube to the source of energy must pass through the glass to the interior of the tube, the same as when a metallic connection enters at the corresponding end of a Geissler tube. For example: if a vacuum tube, having no leading-in wire, be connected by the usual method with a connecting wire to the negative side of a Holtz machine, or a Ruhmkorff coil, the discharge—the cathode stream that passes to the opposite end of the tube—will produce a green spot of fluorescence, if the vacuum of the tube is of sufficiently high vacuum, at the end where the cathode rays impinge, indicating the presence of the X-ray. The same effect will be produced in the end of a tube of the same vacuum having a leading-in wire connected, also, to the negative pole. If either tube is placed against some substantial object, the green fluorescence is immediately transferred to the side of the vacuum tube opposite the place of contact. Another experiment may be made by connecting the positive pole of a Holtz machine or a Ruhmkorff coil with the two kinds of vacuum tubes. The green fluorescence appears at the other extremity of the tube beneath and around the metallic holder of the vacuum tube, or at the place where the wire enters the Geissler tube. It would seem, therefore, that these two experiments produce precisely the same phenomena, whether the current is conducted to the interior of the tube by a metallic connection or not, indicat-

ing that the electrons are admitted through the glass of the tube. These demonstrations and the experiments of Sir Oliver Lodge seem to demonstrate that the negative electrons do pass through the glass of the tube, not exceptionally but invariably.

The various color effects that are produced within the vacuum tubes when the negative electrons are passing, depend upon the degree of the vacuum, except that the volume or richness of the color will be greatest from the sources of large amperage. The color produced, therefore, will be the same in any tube, from whatever source, regardless of quantity or the range of potential that will induce them. It will depend upon the vacuum of the tube, which indicates that various rates of ether vibration are induced by the passage of the cathode rays through media of varying resistance, up to the point where the vacuum becomes so high that these rays cease to pass, when no effect whatever seems to be produced. At this point it is probable that the electrons cease to pass.

The effects of frequency upon the phenomena are evidenced by the observer in recurrent waves of color, which pass synchronously with the rate of the interruption. These waves of discharge are capable of exciting vacuum tubes, which are made to revolve or oscillate back and forth, showing groups of discharge in lines, the size of the hollow of a revolving or oscillating tube, varying in number with the rate of the condenser discharges at which these interruptions occur. To demonstrate this effect take in the hand a narrow vacuum tube connected with a high-potential source, having means of varying

the rate of condenser discharges, and cause it to oscillate back and forth, and note the effect. Groupings of one, two, three, four, or five, or more of these lines of color may be made to appear by varying the frequency and rates of oscillation.

The waves of cathode rays passing with the negative electrons will flow, if the tube is connected to a source of sufficient energy, in recurrent clusters or groups of oscillations passing through the dielectric to the object. These waves are synchronous with the interruption at the spark-gap of a static machine or resonator, or a mechanical interrupter of a Ruhmkorff coil. For making this experiment a very small vacuum tube may be attached to the stem of a metronome, which may be regulated to oscillate at a given rate.

The chemical effects of these vacuum-tube discharges are the production of various combinations characteristic of electrical discharges in the atmosphere—derived from the expenditure of energy upon the air, and a change in the conditions of electrons now known to be substantial things—producing NO_x , O_x , H_2O —and other products of less significance. The color of these discharges as they pass through the air is usually violet, but varies somewhat with the intensity of the discharges to almost white. Various other physical effects are produced which depend upon the sources. When connected *directly* to the static machine, discharges through short air-spaces produce a decidedly irritating and stinging sensation as they escape from the surface. The discharge is in bunches or multiple oscillations, in number relative to the length of the air-

gap between the tube and the patient, the frequency of the spark-gap discharge, and the volume of current passing. When discharged from a resonator, however, the potential of delivery, the spark length that can be administered, will be slightly longer than the spark-gap between the condensers of the resonator and be accompanied by a multitude of less intense oscillations and frequencies. These discharges will vary with the type of resonator or solenoid and current source employed.

The convective discharges from the vacuum tubes, when derived by direct connection with a Ruhmkorff coil, are very numerous and produce a severe burning sensation, unbearable when held at a short distance from the skin.

The color of the convective discharges varies with the intensity, i. e., the color of the discharge between the tube and the body.

By connection with resonators and solenoids the intensity of these discharges may be greatly varied and the number of oscillations greatly multiplied, giving these currents, as well as those of the static machine, the right to be termed high-frequency discharges, i. e., from the standpoint of the great number of oscillations emanating from the apparatus.

The physiological effects of these vacuum-tube discharges are varied, depending upon the source of electrical energy and the character of the resonator or solenoid, which intervenes between the exciting apparatus and the surface to which the discharges are applied.

(1) *The effects are of a stimulating character, produc-*

ing a local irritating action which stimulates the superficial tissue when applied, because of the immediate irritating effect of the discharges, and are distinctly rubefacient. Locally there are also the effects of the chemical action of the discharges which are produced by the passage through the air or dielectric. These stimulating effects to the periphery, especially when applied to motor points, produce reflex muscular contraction, as well as other reflex effects, to which undoubtedly the constitutional, clinically demonstrated, action of the discharges from vacuum tubes may be largely attributed. When, however, the application is made to the surface of the body, either with the patient holding an electrode connected with the resonator, or when the electrode is applied without such contact, the patient receives inductively and conducts from the surrounding capacity to the point of discharge currents of equal potential of the opposite polarity through or over the tissues of the body, according as the frequency is low or high.

(2) *The rubefacient effects* of these discharges are pronounced in character, and when excited by the vacuum tube held a short distance from the surface or from the spark of the resonator, they produce a marked degree of local counter irritation and more, because the local effects of these discharges are clinically demonstrated to influence metabolic processes in the integument, restoring, to a remarkable degree, normal conditions. The action may be carried, however, so far as to produce distinctly cauterant effects.

They may be so administered as to cauterize the tissues

from almost any source, the time required varying with the amperage of the current, other things being equal. That this action should be considered as comparable to the X-ray, as one author has suggested, is a serious mistake. That necrotic conditions are exerted by both is admitted, but as well say that the application of an actual cautery produces the same effects as the X-ray when they arise from entirely different conditions.

(3) *The antiseptic action* of these discharges is due to the influence of the chemical products of the discharges produced by the passage of electricity through the air-gaps, and the action of the chemical rays associated with the discharges. The radiations have been reported by various authorities as penetrating the tissues from one to three millimeters. They are peculiarly effective in the destruction of germs which are susceptible to the influences of light, as are the gonococci. The extent, however, of the antiseptic action has not been fully demonstrated. The chemical effects of the products of atmospheric and electric decomposition are fairly energetic, when brought in close relation with the tissues, as when vacuum tubes are placed in the cavities of the body, when, to obtain the best results, the glass should be large enough to smooth out the rugæ of the mucous membrane in order to bring the discharges in immediate contact with the germs that may be present. The nascent nitrous acid (NO_2) is produced in such infinitesimal particles that even when it immediately unites with the water (H_2O) present and forms nitric acid (H_2NO_3), it is not in sufficient quantity to cause disagreeable irritation to the tissues unless the adminis-

trations are prolonged. The time of application may be varied, however, from five to fifteen minutes according to the amperage of the current employed. The current of larger amperage produces a much richer discharge and consequently one which is productive of a greater degree of chemical effect.

(4) *The analgesic action* is due largely to the effect upon local inflammatory conditions. There is also an anæsthetic or numbing influence upon the superficial tissues, which relieves to a large extent local irritability, and by causing an ulcerated surface to become superficially covered with a glossy film (resembling a coating of collodion) which remains after the applications, thereby protects the surface from local irritation.

(5) *The effects upon local metabolism* are due largely to the induction of muscular and tissue contraction and the vibratory influences, coincidently affecting local stasis and congestion. These effects are most marked when the vacuum electrodes are in contact with the tissues, and the current is produced by direct connection with the static machine (with coil currents active contraction is not produced). By this means existing induration and infiltration are dissipated, the tissues become softened, and the circulation is restored as to the margin of an ulcer and local *repair* is instituted. The same influence produces an increased elimination of the products of inflammation, thereby assisting the process of reconstruction. Congestion is relieved and restoration of ulcerated and indurated regions to a normal condition is effected, in cases which are not malignant or too chronic or deeply seated in char-

acter. When application is made repeatedly, with vacuum-tube discharges, to the surface of the body, the skin beneath the epithelium becomes pigmented, a condition which may persist for considerable time, but is, as a rule, finally absorbed as is tanning by the sun's rays, to which it is analogous.

(6) *Muscular and tissue contraction and local vibration* are produced by these vacuum-tube discharges to a marked degree when derived directly from one side of the static machine, when a spark in the circuit is discharging at the spark-gap. These effects of muscular and tissue contraction and local vibration, so valuable in therapeutics for the production of increased local metabolism and elimination, as well as the restoration of muscular tone, *are not so well produced by connection in any other manner or to any other apparatus that has been produced, as to the static machine in the manner above described.* It should be understood that it is not necessary that the patient be insulated during the administration of this modality.

The muscular contraction and vibration produced in the above manner is greatly accentuated by grounding the opposite side of the machine—the one not connected to the patient. Muscular and *protoplasmic* contractions reflex in character may also be induced by convective discharges when applied to the surface from the tube held at a short distance. The sparks administered from a resonator, or solenoid, either with a coil or static machine, will produce marked muscular and protoplasmic contraction.

The indications for superficial application are for the treatment of local skin and superficial inflammatory affections. The administration of the coil or resonator currents from the vacuum tubes in close contact with the tissues produces to a very slight extent, if any, appreciable muscular contraction, and they are not sufficiently energetic to be of therapeutic value.

There is a marked contraction of superficial cell protoplasm from the resonator sparks from either of these sources, and owing to the larger amperage of current, this is more marked in a given length of time from the coil than from the static machine. The effect of this modality makes the coil current valuable, also, in the treatment of superficial inflammatory conditions.

Those who employ coils, as shown in the reports of results in the writer's possession, obtained from numerous observers employing vacuum tubes, are having a smaller percentage of success from the treatment of inflammatory conditions—either those employing the coil or static currents from resonators—than those who employ the current directly from one side of a static machine, employing the usual grounding to the opposite side. In this connection it should be emphasized, then, that whenever it is desirable to produce this effect of tissue and muscular contraction and vibration for the relief of local inflammatory conditions, the current should *not* be derived from a resonator or step-up coil, but when possible *directly from the static machine, one side of which is provided with a good metallic grounding*. This is an important observation in connection with the application of vacuum tubes and is

the indication for the choice of methods for the treatment of non-malignant, suppurating, or tubercular conditions when not too deeply seated. The latter demand the more energetic modalities—the wave-current or indirect sparks.

(7) *The local production* of heat arising from the action of the current is due to the chemical influence of the discharges in the very minute air-spaces which exist in the tissues, and to the effect of the heating of the glass from the passage of the discharges. Some heat is also, undoubtedly, produced by the passage of the current through the tissues and is insignificant or marked, relative to the amperage employed.

The therapeutic indications for the employment of the vacuum tubes, as suggested by the foregoing physical and physiological effects, is important, especially, for the treatment of superficial skin conditions and ulcerative and inflammatory processes in the cavities of the body:

(1) *For the relief of superficial local congestion and induration*, as suggested above, satisfactory results are obtained. The method is especially adapted to affections of the mucous surfaces and is usually administered by applying the vacuum tubes in close contact with the tissues. The current of the static machine, when employed in these cases as the source of the high-potential current, accomplishes the best results. Those who employ coils may obtain excellent results, though not equally good, from the use of the vacuum tubes in these conditions. With the static machine these vacuum tubes may be used either as described, connected directly to one side of the

Holtz machine, the opposite side being grounded, or it will be found convenient in many cases, and equally good results may be obtained by connecting it directly with the outer coating of one of the Leyden jars, when using the static induced current. A metal electrode may then be placed, if desirable, upon one part of the body of the patient, and the vacuum tube in position in the rectum or vagina, or, if desirable, two vacuum tubes may be used simultaneously. When this is done, either with one metal electrode or two vacuum tubes, the local effects may be regulated by varying the sizes of the Leyden jars, which are connected to the two electrodes; for example, if a metal plate has been placed upon the abdomen, or over the liver of the patient, and another one in the rectum for the treatment of a local condition in that region and the machine started. (See Frontispiece.) When regulating the current to the demands of the case, a distinct vibratory effect should be appreciated in the rectum. If to induce this effect too great muscular contraction is produced beneath the metal plate which has been placed upon the abdomen, a smaller-sized Leyden jar should be placed upon the side to which the cord connected with the electrode on the abdomen is attached, or a larger one may be placed upon the other side and a shorter spark-gap employed. By using the three sizes of Leyden jars provided with static machines and varying them to suit the conditions, it will often be possible to produce desirable local conditions without discomfort to the patient. By variously regulating the application of the current, two patients may be treated at the same time with the static

induced current, if it should be desirable to do so for economy of time.

Another method of producing muscular contraction for the relief of local congestion—the method which is employed successfully to the surface—is to apply the sparks from a high-potential resonator in connection with a coil or static machine. The application of these short sparks, from either source, should be made to the parts affected, but should never be made too painful. For using this method with either high-potential resonators or solenoids, the apparatus should be capable of delivering sparks one-half to one and one-half inches in length. These may as well be applied when using a static resonator from a small brass ball, when the sparks are more energetic. The effect of contraction from these applications is most marked—especially of cell protoplasm, the tissues taking on a condition of marked contraction expressing serous contents from the œdematous tissue or pustule, thereby rendering a valuable service in the treatment of various skin conditions. These applications are valuable in the treatment of felons, tonsillitis, and other abscesses in the early stages; for the relief of congestion in the small joints, as in cases of the treatment of rheumatoid arthritis, for the production locally of small blisters, for the removal of moles and freckles, and in the treatment of numerous skin diseases, notably the types of lupus, eczema, superficial ulcers, angiomas, etc.

(2) *For the restoration of normal secretion in the skin and mucous cavities to which the application is made, these high-potential modalities are valuable. The same*

rule obtains here as in the treatment of inflammatory conditions with reference to the production of local tissue contraction and vibration, the vacuum tubes with static current and relatively painless resonator sparks, static or coil, producing the best results.

(3) *To relieve excessive secretion*, restoring tonic conditions to the tissues by the production of contraction of cell protoplasm with the expression of redundant secretions such as are found in eczema, no measure is more valuable than the short resonator sparks applied extensively over the affected region. The parts will continue to ooze for a considerable time after the cessation of the administration, so that subsequently the reduction of the œdema will be marked. For the increase of superficial local metabolism the application of the resonator sparks is effective by the induction of vibration and muscular contraction.

The relief of swelling and induration and institution of tissue repair are remarkably demonstrated in the treatment of ulcerations of accessible mucous cavities. The administrations are especially valuable in the treatment of various ulcerative and congested conditions in the cavities of the body with the vacuum tube in contact with the affected areas. Externally the application of the short resonator sparks produced by the so-called high-potential apparatus, alone or in connection with a solenoid, are to be preferred if the vacuum tubes are to be employed.

(4) *To the treatment of local specific conditions* in which the parts affected are superficially located, no modality affords better promise of success than the small

resonator spark, either from the vacuum tube or a metal or carbon electrode. In the treatment of these conditions the necessity for a current which will produce muscular contraction and vibration is not so important. Where conditions of impaired metabolism are present, vibratory and contraction effects, however, do promote the elimination of effete and toxic materials, and increase local leucocytosis, thereby facilitating the restoration of normal conditions. The antiseptic effects are due, as explained above, to the chemical products of the discharges, as they are produced in the interstices in the superficial structures by the decomposition of gases, to the action of the rays of light upon the tissues and the germs, to which in many cases they are destructive, and to the increased resistance of the tissues. By these methods the processes which are acting as local sources of irritation are destroyed and reparative action instituted.

(5) *The cataphoric action* of the vacuum-tube discharges when the tubes are placed in close relation to the tissues, or from the application of the resonator sparks, has been demonstrated by Drs. Francis B. Bishop and J. H. Burch, and may be verified by anyone who wishes to make the experiment. The extent, therefore, to which this sort of action is valuable, is one open to careful study. The indication for the use of iodine or other local germicides in the treatment of specific conditions will depend upon the failure to succeed by simpler methods. Failing to relieve the conditions by the application of high-potential discharges alone, it will certainly be proper and scientific to resort to the employment of cataphoric methods, mild

though they be. Marked success has been obtained in the treatment of Riggs' disease by this method.

(6) *For the relief of pain*, the same general principles obtain as for the relief of inflammatory conditions, with the advantage also that these applications produce, as stated above, a coating upon the outside of the surface due to the contraction of the superficial protoplasm. This effect in a large measure resembles a coating of collodion which protects the ulcerated surface against irritating secretions. Conditions of neuralgia, arising from impaired elimination of toxins, due to various causes, may be relieved by either general or local applications of these modalities. For the improvement of local metabolism, these and other high-potential methods of application afford a valuable means. For the effects upon general metabolism local applications of this sort, however, are not of nearly so great value as other methods of applying these currents.

The field of indications for the employment of vacuum-tube discharges as suggested is large indeed and worthy of general recognition by the medical profession.

CHAPTER VII

HIGH-FREQUENCY CURRENTS BY AUTO-CONDUCTION AND AUTO-CONDENSATION METHODS

Auto-conduction—advocated by D'Arsonval—is a method of application by which the patient is never in direct contact with either pole of a high-potential source



FIG. 14. Auto-condensation Chair.

of electrical energy, but in an electrical field within a solenoid or in proximity to the opposite polarities of a current of high frequency and high potential. D'Arsonval's method of administration was to apply the current to the patient while resting upon an auto-condensation

couch or chair (see Fig. 14), the current passing through coils surrounding the couch upon which the patient was

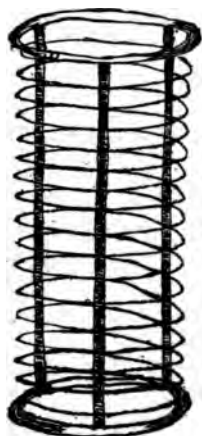


FIG. 15. Solenoid.

resting. A method in more common practice and more energetic is the employment of a large enough solenoid dropped over and around the surface of the patient either seated or standing within the solenoid. (See Fig. 15.) This may be done either by connection with a static machine or coil. Another method is arranged in which currents are not passing, but the negative and positive are on opposite sides of the

patient and insulated by the air on one side and by the insulated cushion on the other. The patient is placed upon an auto-condensation couch or chair, upon a felt cushion which is placed over a plate of metal five feet long by sixteen to twenty inches in width, and suspended over him is placed a wire *half-cage*, as shown in Plate IV. The positive side of the coil or static machine is connected to the cage and the negative to the metal plate, beneath the patient, thereby placing the patient in an electro-static field of high potential. This may be done either with the coil or static machine, as shown in Plates IV and V. The value of this method, if there was not a better one—the static wave-current—for treatment would be of considerable value in therapeutics and is a valuable method at the command of those who employ high-potential coils. *The effects of auto-conduction* are to increase to a degree the general metabolism

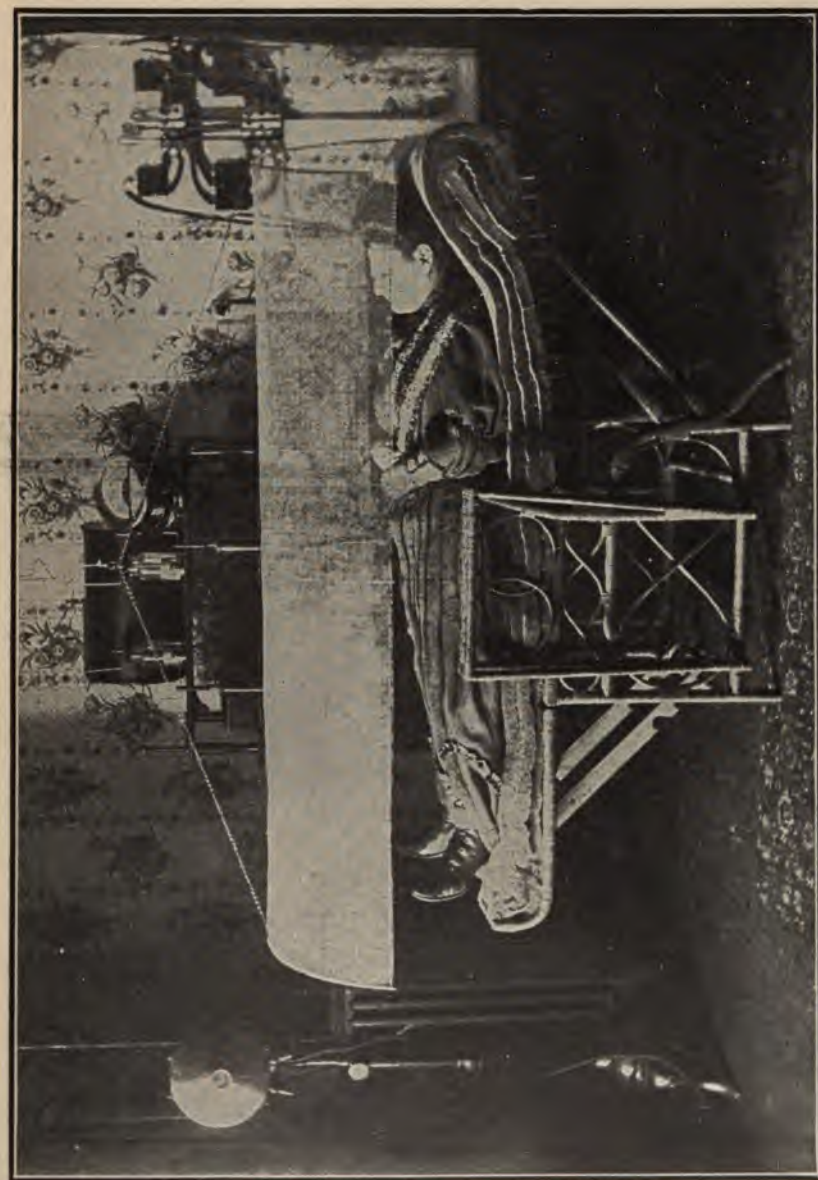


PLATE IV. Auto-conduction Method. Sheet of Metal beneath Felt Insulation Connected to One Pole of Apparatus and Half-cage Wire Screen to the Other.

by inducing in some way functional activity. The *modus operandi* is obscure and uncertain. It has been demonstrated by Dr. Herdman, of Ann Arbor, however, in his experiments with solenoids, that very positive effects are produced upon the growth and development of animals and human beings when placed for a short period each day within the solenoid. These experiments were made in a very careful and scientific manner and demonstrated beyond question the influence of such currents upon general nutrition and metabolism.

The *auto-condensation method of d'Arsonval* is applied to the patient lying upon an auto-condensation couch or chair (see Plate V) provided with a sheet of metal over which is placed a cushion of insulating material, as felt or rubber waste. One pole of a high-potential current is attached to the large insulated metal plate, and the other by a bifurcated cord having an electrode at each extremity held in the hands of the patient. The currents of high frequency often having a current strength as great as 500 to 800 milliamperes are then administered for periods of ten to fifteen minutes. It is claimed by d'Arsonval that by this method very pronounced effects were produced upon the general metabolism, increasing the elimination of solids and carbon dioxide and also producing marked effects upon general nutrition. No claim was made that by either this method or the auto-conduction method any action was effected upon local inflammatory processes, the effects being generally referred to the systemic action, which influenced the nutritive and metabolic processes. The claims of d'Arsonval have

been controverted by numerous authorities, while others steadfastly maintain that his claims are well founded.

The writer's experience with that method of treatment is not such that he feels justified in expressing a personal opinion. The method is indicated in accordance with the technique of d'Arsonval by those who have coils and not static machines. For those who have static machines the most rational method is the systematic employment of the static wave-current because it combines both the local and constitutional actions. There is rarely a case in which there is an indication to treat a constitutional condition without the presence of some local, discoverable, or suspected inflammatory process, acute or subacute, for the relief of which the application of the high-potential wave-current or other modality producing local mechanical effects would not also be indicated, whereas there is no marked local effect derivable from the auto-condensation method.

A method of employing auto-condensation in connection with the static machine may be accomplished as follows, if desirable. Place the patient upon a chair which is as nearly as possible a non-conductor, or the chair upon an insulated platform, though in reality it makes but little difference—as the two polarities are certain to be brought in proximity inductively by the method to be described. Place upon the chair or table a sheet of metal about five feet long and sixteen to twenty inches in width, with some insulating material, as a piece of felt three or four inches in thickness or a cushion, made of rubber waste, covered with leather or silk long enough to cover it. Upon the



PLATE V. Static Auto-conduction. Metal Plate beneath Felt Cushion Connected to Positive Pole; Negative Grounded, Half-cage Suspended and Grounded. Spark Discharging at Spark-gap.

surface of the patient, preferably over the region of the liver or abdomen, or other region which may call for local treatment, place a metal electrode about six by eight inches in size, and connect it directly to the positive side of the static machine. Then either connect the metal beneath the cushion directly to the negative side of the machine, or ground that side of the machine and connect another ground chain to the plate beneath the cushion. The spark-gap may then be permitted to discharge, administering the wave-current over the abdomen with the patient placed in this manner in an electro-static field as described, or the current may be administered without a spark discharging. In one instance the method simulates a static bath or static insulation and in the other the wave-current. There are no particular advantages to be derived from this method over the ordinary administration of the wave-current. If, however, it is felt desirable to employ auto-condensation it may be accomplished by the static machine in the manner described (see Plate VI), or it may be done in connection with a static high-frequency apparatus.

The therapeutic indications for auto-condensation are for the treatment of atonic states or conditions in which, from inactivity and improper habits of life, the secretions have become inactive, as in rheumatic and gouty affections.

The success of Riviere and Chisholm Williams in the treatment of tuberculosis indicates the employment of auto-condensation in that disease.

The employment of various modern devices in connection with high-frequency apparatus, as the Jackson,

Meyrowitz, and Ovington (shown in Figs. 16, 17, and 18) types of alternating high-frequency apparatus employing



FIG. 16. The Jackson Coil.

currents of large milliamperage and inducing strong peripheral stimulation by the employment of vacuum tubes, is another more recent method of administering high-frequency currents which simulate in many respects the high-frequency administration of Oudin and d'Arsonval. Various types of resonators are used also in connection with X-ray coils, producing practically the same results as the so-called high-frequency apparatus with or without the employment of auto-con-

densation. (See Figs. 6, 7, and 8).

It rests with the physician who purchases an apparatus to determine whether, if he is to secure a coil, he will require it largely for the use of the X-ray for practical radiography and make secondary the use of his apparatus for high frequency, or whether he wishes to buy an apparatus for the sake of employing these alternating currents, which apparatus is also provided with X-ray attachments but not capable of producing rapid and most satisfactory radiography. In other words, the special high-frequency apparatus may be also used for radiotherapy, but for radiography have about the same X-ray capacity as a static machine. The high-potential applications from vacuum tubes in connection with various



PLATE VI. Auto-condensation. Metal Plate beneath Felt Cushion Connected to One Pole of Resonator. Large Metal Plate upon Bared Abdomen (preferable to Bifurcated Cord in Hands) to the other Pole.

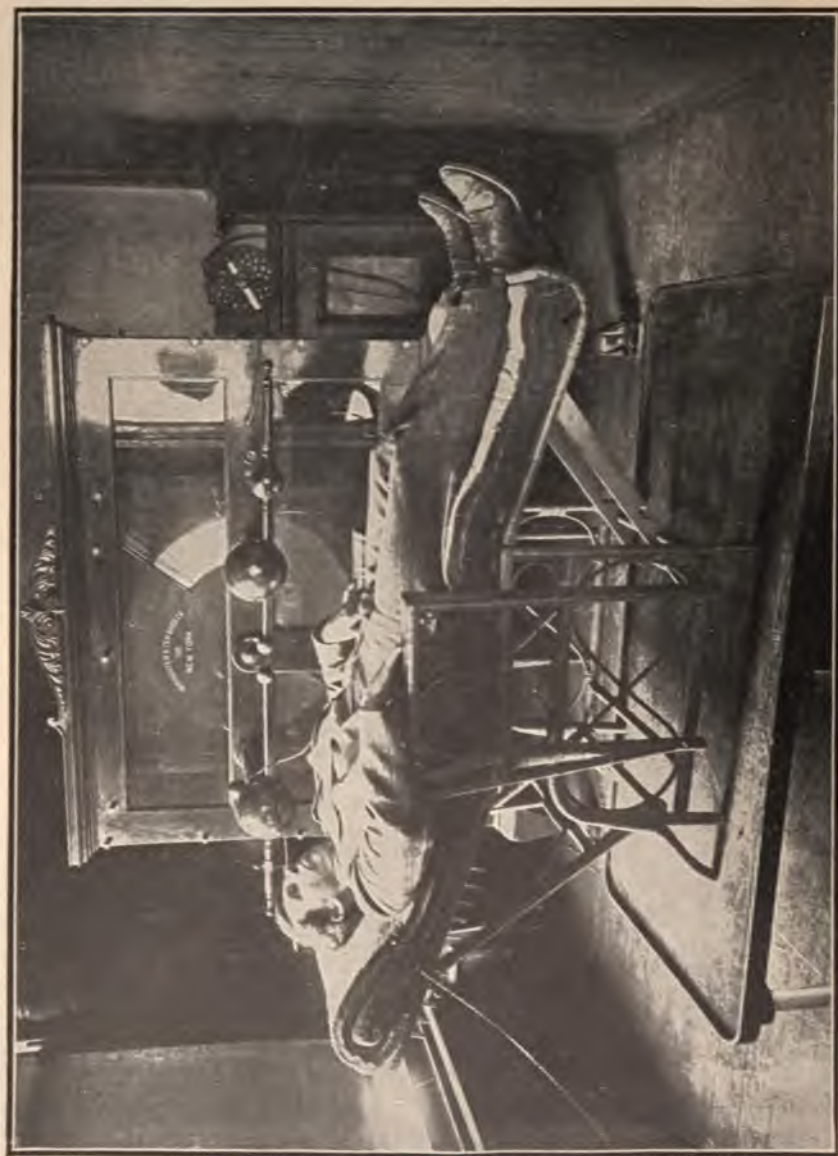


PLATE VII. Static Auto-condensation. Metal Plate beneath Felt Grounded. Abdominal Electrode (Large Metal Plate over Abdomen) Connected to Positive Pole. Negative Grounded, Spark Passing at Spark-gap.

high-frequency apparatus produce a degree of active superficial stimulation which is beneficial in many super-

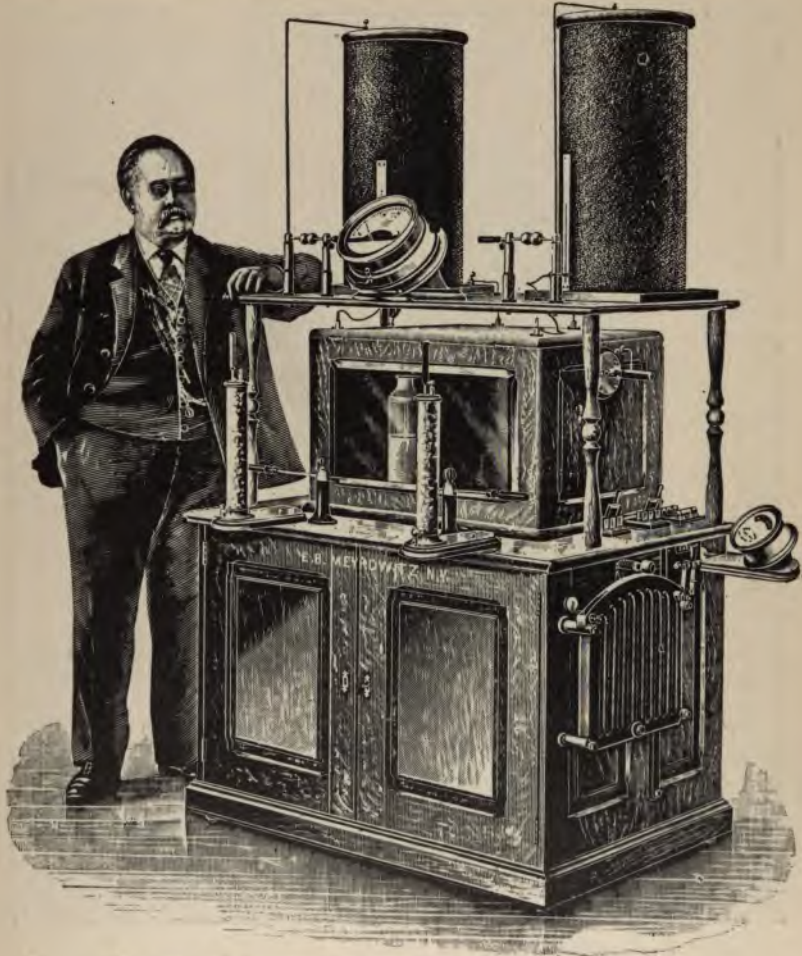


FIG. 17. Meyrowitz Coil and High-frequency Apparatus.

ficial conditions. That they pass through the tissues of the body and produce the active mechanical effects of the static modalities is very doubtful.

It has been demonstrated that it is possible, however, to produce in the treatment of tuberculosis a reaction as



FIG. 18. Method of Treating Tuberculosis with High-frequency Apparatus (Ovington Apparatus); Patient Connected to One Pole through Electrode in Hand. Application with Vacuum Tube to Chest, Front, and Back.

described by Riviere and Chisholm Williams, with an increase of temperature in these cases after the first or

second application to be followed by gradual deferescence. The same effect is produced by the method shown in Fig. 18. This reaction seems to indicate a beneficial effect either in the tubercular process or by improving the general resistance of the patients, enabling them to throw off the toxins produced by the tubercle bacillus or to so increase the resistance of the tissues that the germs are destroyed. The application of the vacuum tubes from the static machine, employing a large surface electrode over the chest or abdomen, produces similar results, with the additional effect of muscular contractions and distinct vibration affecting the superficial layers of muscles relative to the length of the spark-gap that can be employed.

With the various types of high-potential apparatus, it will be appreciated that the methods by auto-condensation and auto-conduction can be readily administered. The method as employed by d'Arsonval presupposes the employment of *alternating* high-frequency currents; no other current can be properly a *high-frequency* current. The methods employing the static currents, as shown above, are not alternating, but can be administered of alternating character when used in connection with the static induced current. That method, however, does not appeal to the writer as so valuable as the method described in this chapter. With the alternating currents no choice of polarity can be exercised in the administration. The importance of the consideration of polarity has been considered elsewhere in the body of the work.

The determination of the field for application of the various methods will call for much careful investigation and comparison of results. Apparatus then will not be constructed according to the caprice of the manufacturer, but to meet the demand of an intelligent profession.

CHAPTER VIII

THE PHYSICAL EFFECTS OF THE HIGH-POTENTIAL CURRENTS

The physical effects of electrical discharges as applied in therapeutics depend largely upon their capacity to penetrate the body and the nature of their behavior when brought in relation to normal tissue under varying conditions; such effects depending upon the varying characteristics of both the currents and the tissues in accordance with physical laws. The study of these actions is fraught with less difficulty than the study of the actions of medicinal agents employed in therapeutics, because definite physical laws govern the activity, diffusion, and effects produced. The action of currents and other discharges upon animal tissue is generally demonstrable, certain, and reliable. Once proved that tissue contracts under an electrical stimulus, either by action upon the cell or the muscular mass, the same effect will, under normal conditions, be constant wherever muscular structures are found, deep-seated or superficial. We are thus enabled to determine with certainty the action of these currents upon the deeper-seated structures when we have learned by experience to employ the requisite potential, amperage, and frequency to affect them. So also is superficial cellular activity,—general or local metabolism,—is mechanically increased, the rule will be established that organs elsewhere, composed of the same tissue elements

under like conditions, will respond in the same manner when submitted to the same action. It is only necessary, then, to demonstrate definite effects when they become established laws, and we are enabled to anticipate and account for results with comparative accuracy. The application of electricity, when its laws of action and control are discovered, together with the relative effects of potential quantity and rate of discharge, becomes one of the most rational and reliable therapeutic procedures.

The physical effects of electricity upon animal tissue must depend relatively upon the characteristics of the modalities employed. The ratio of quantity (amperage) and potential (voltage) of the current determines, if high frequency does not render the action superficial, whether its action will be destructive (cauterant), electrolytic to a large extent, or act as a simple stimulant or *vis-a-tergo*, inducing increased functional activity.

The nerves, either sympathetic or cerebro-spinal, cannot be considered as electrical conductors conveying currents to their points of distribution. They are affected, on the other hand, as by a stimulant which excites the neuron and its axis cylinder to its characteristic action. There has been no demonstration, though often so inferred, which will justify the position that the nervous system acts in any way in conjunction with electricity as conductors *per se*. On the contrary, the arrangement of the nervous system is not such as will warrant such an hypothesis, ending as it does in terminal neurons without circuits. The centripetal and centrifugal impulses cannot by inference or demonstration be shown to bear any rela-

tion to electrical circuits; on the contrary, it has been demonstrated that nervous tissue is not the best conductor of electrical currents, but the tissues containing the largest vascular supply, as the blood vessels and muscles. Furthermore, nervous impulses are relatively very slow in passage as compared with the velocity of electric currents. It is of great importance in the consideration of the physical actions of electricity that we should recognize the behavior of the various electrical phenomena under different conditions, in order that we may accurately determine its destination, physical action, and physiological effects.

Currents of different potentials perform differently in their passage through the tissues. Static currents of *high potential* are *universally diffused* through the body when administered to a patient insulated and placed in direct connection from one side of the source of energy through an electrode or other connection coming in contact with an electrode placed somewhere upon the surface of the body, in accord with the law that such currents seek to immediately surround instead of occupy a conducting medium in a state of charge. They pass to the surface by the tracks of relatively least resistance and *in nearly straight lines* through substances having but slight variation in resistance, as do the relatively homogeneous tissues of the human body. Currents of *low potential*, on the other hand, *do not seem to enter the tissues at all* when connected with but one pole of a source of electrical energy. When such currents as those derived from the continuous-current battery pass between the two poles,

the current is *diffused into the tissues* laterally, as a sluggish stream coursing through a flat low land.

Two essential properties of all electrical currents affecting their action are the voltage (E. M. F.) or potential and amperage (quantity).

Currents of great potential and large quantity cauterize the tissues and destroy life by shock, overwhelming the cardiac or respiratory centers or by processes of disassociation of normal arrangements or conversion into other combinations.

Currents of very large amperage and relatively low potential are also capable of producing the same effects. These effects are also produced by currents of *relatively small* though not infinitesimal *amperage*, but having *extremely great voltage or potential*. When, however, the amperage of a current is so small as 1-5000 to 1-2000 of an ampere, the *voltage* or potential may be in *millions* and produce no dangerous effect. The latter are the currents of *high potential* without reference to frequency which are of great value therapeutically because they are capable of great diffusion mechanically, inducing activity of primitive cells and of the structures of which they form a part.

Frequency of oscillation or alternation, it has been shown by Tesla and others, renders currents of relatively large amperage and high potential not dangerous to life. This seems to be demonstrated to be due to the fact that these currents are, owing to great frequency, forced to pass over the surface of the body without altering even the superficial structures.

Cauterant effects of high-potential currents are produced by discharges derived from a source of relatively large amperage when brought near the surface, or by successive discharges of smaller amperage to the same area. This effect is produced by bringing the effleuve or brush-discharge from sources of high potential, in close proximity to the tissues—holding an electrode for a sufficient time in one position. The destructive actions and cauterant effects of these modalities are of relatively little therapeutic value, except possibly when it is sought to destroy local infection, a neoplasm, chondylomata, or other superficial abnormal process.

Electrolytic action is produced to varying extents by all electrical modalities, except possibly those in which the tissues are subjected to the action of currents of but one polarity, as the static wave-current and currents which do not pass into the body.

With the currents of larger amperage, however, electrolysis is most potent and of great value for producing the therapeutic results which are sought from such currents, but great caution against the reckless employment of currents of large quantity must be exercised. In the treatment of conditions in which it is sought to improve metabolism and increase the activity of organic functions, currents which produce ionic alteration without reference to consequence or selections, as do currents of larger amperage, must be employed with caution.

Cataphoresis, as produced by currents of high potential, is a subject upon which relatively little has been contributed. It has been demonstrated, however, by Bishop,

Burch, and others, that it is possible to introduce by such currents chemical agents such as iodine into the tissues.

A stimulating influence capable of inducing general systemic activity demands a current of very high potential, and for safety, such currents, if they really do pervade the tissues, *as electrical currents*, should be currents of very small amperage (1-4000 to 1-2000 of an ampere). It is probable that electrical charges under high pressure are capable of as great a degree of diffusion as chemical diffusion in liquids. This makes it possible to induce physical effects which, when properly administered from a capable source of electrical energy and applied to a homogeneous substance (the body is practically a normal salt solution), will be generally diffused throughout the tissue, in its passage to and fro from the surface of the electrode, if the subject is insulated, and the current from one pole of the source of energy made to enter the body over a small area. It is this property of the action of the *static wave-current* which makes it possible by its use to induce remarkably beneficial results upon general metabolism.

Muscular contractions induced by all electrical currents, except the currents of high frequency, are caused either by the stimulation of the centers either direct or by stimulation of a nerve trunk most active at the motor points, or of the end neurons, resulting in the production of reflex action, when conveyed to and from the responsive centers in the cord.

Contractions of cell protoplasm without reference to the neurons are undoubtedly produced by electrical

modalities, particularly those of high potential. The character of the contractions induced by electrical stimuli varies materially with the current or discharges employed; high-potential currents producing diffuse painless contraction, while currents of lower potential are associated with more gross and painful effects. The conductive discharges from high-potential sources applied through the intervening metal electrodes are usually painless when placed in contact with the surface of the body. The contractions produced under these circumstances do not result from irritating stimuli, but are due to the action upon the cells characteristic of high-potential electrical currents.

The effleuve as emitted from the brush-discharge, sprays, and vacuum electrodes are distinctively irritating to the surface and produce a rubefacient condition, and their consequent action upon deeper structures is at least in part due to reflex stimulation.

Local oxidation and other germicidal action due to the affinity of O_3 (ozone) for the organic tissues is another action which is exerted beneficially upon abnormal tissues and the germs present when exposed to the applications of the effleuve of the high-potential discharges due to the decomposition of the atmosphere and the products evolved from the mingling of the positive and negative electrons in proximity to the tissues with the production of ozone, nitrous acid (NO), water, and other combinations of less importance. The characteristic chemical effects are of a character which is but moderately irritating from the production of H_2NO_2 by the combination of

NO, and water, which is produced in such small particles as not to seriously affect the tissues if the administrations are not too prolonged.

The vibratory action induced by the discharges of high potential arises from various causes. (1) Protoplasmic contraction is produced in the tissues by the current as it passes. (2) Superficial intense vibration is exerted by the action of the discharges upon the patient, insulated but in the presence of oppositely charged capacities, and (3) the intervening skin, which is a relatively poor conductor, offers resistance, and the current passes beyond to a medium of good conduction. The effects are to set both the skin and underlying tissues into a state of vibration synchronous with the impulses of the interruption or oscillation at the spark-gap during the administration. The difference is marked between the skin and mucous membrane, the resistance being much less with the latter.

Intense local vibration is most marked as produced by the conductive discharges at the place of contact with the metal electrode usually employed during the administrations of the static induced and static wave-currents, and also with the conductive feature of currents derived from the vacuum tubes connected directly with the static machine without the intervention of a step-up transformer or resonator. The effects of sensible vibration are not so energetically produced by any other electrical apparatus as by the currents of the static machine.

Polarization is one of the most difficult of the physical properties to demonstrate. It has been shown, however, by physicists that electrical currents in their passage

through the tissues induce cell protoplasm to take spherical forms. All are familiar with the physical demonstration that magnetism and electrical discharges induce movable particles of matter to arrange themselves into various symmetrical forms. These actions signify an influence of electrical force by which mechanical effects are exerted.

Ionization. The demonstration by Thomson that the passage of an electrical current is the passage of substantial electrons is certain to place new constructions upon the probable actions of the currents upon the tissues.

The physiological effects of the various high-potential modalities derived from static machines and coils, either by direct connection or with intervening resonators or step-up transformers placed in the circuit, are practically based upon the same general principles, except those due to individual peculiarities, and have therefore been classified with reference to their characteristics as conductive, disruptive, and convective discharges, with added reference to the various sources and the varying conditions of the modalities. The effects produced by these electrical discharges are variable with the different modalities and have been given in detail in the preceding chapters.

CHAPTER IX

GENERAL PRINCIPLES GOVERNING THE THERAPEUTIC APPLICATION OF HIGH-POTENTIAL CURRENTS

THE consideration of the physiological actions as outlined in the foregoing chapters, suggests a very wide scope of clinical application for the high-potential modalities. It has been observed that these currents possess three distinct characteristics of action, as follows: (1) the effects associated with *ionization*, *polarization*, and other characteristic actions of electricity; (2) other *mechanical effects* associated with muscular and cell contraction and vibration; and (3) *chemical or antiseptic effects* characteristic of the convective and vacuum-tube discharges.

If these currents are to affect the deeper tissues of the patient and produce a general effect, it is necessary either that the current administered be applied to the patient when insulated, and from one side of the source of electrical energy or by some other method by which it may be demonstrated to be diffused throughout the body.

The wave-current, administered as it is from one side of the machine with the patient insulated, induces discharges which diverge from the surface of contact to the whole surface of the patient, passing through the tissues of the body in every direction, thereby producing a general

electrification. It is in this manner that the influences of electricity *per se* are brought to bear upon the cell structures throughout the whole economy. While the action upon the cell is largely speculative, it is clinically demonstrated from this method of administration that metabolism is increased and a general feeling of well-being induced. It is also clinically shown that patients not affected with organic lesions when receiving courses of treatment, have the normal functions of the system restored. This is evidenced by the markedly increased elimination and secretion, increased body weight, and a gradual restoration to normal proportions of the elements of the blood. These clinical observations indicate that a general increase of cell activity with restoration of their normal action is induced. When it is observed that this may take place regardless of a regulation of exercise and habit, it would seem that these administrations to patients whose habits and vocations are sedentary, take the place in a measure of physical exercise, probably due to the induced activity of the cell, which tends to preserve a balance in the economy furnishing a valuable means of eliminating effete end products and forcing tissue combustion. When employed, however, in conjunction with exercise, greater benefit may be derived. These observations therefore suggest that the person in a relative condition of health, but following a sedentary life, can be greatly benefited by the regular employment of such administrations. In the helpless invalid who is unable to take exercise, they are invaluable in that they induce nature to the active performances of her normal functions.

It has been observed by those who have large experience in the application of electricity by the *auto-condensation* method in connection with the currents of high potential and high frequency that there is also an increase of the products of the end-organs derived from its administration. That these currents penetrate in the same manner the economy, however, there seems to be some question. It seems to have been demonstrated that under both types of administration there is an increased elimination of solids in the urine and of CO₂ with respiration, which may arise from a large degree of heat production or superficial action, and these superficial currents may also reflexly affect the deeper structures of the body or induce other currents in the body. In the case, however, of a current administered as the wave-current is, from one side of the source of energy with the patient insulated, the current can be demonstrated to be actually driven through the tissues in all directions in the natural course to the surface, and the increased elimination so marked with this form of administration is undoubtedly due to the increased activity effecting an acceleration of general metabolism, both eliminative and secretive. These influences associated with the passage of the current through the tissues are productive more or less of electrolysis or ionization. The relative bearing of this action, however, upon the tissues is one concerning which no observations except the clinical results of their employment can be made. It is probable that the cells under the influences of the current, passing with interruptions, is one that induces a change of form incident to the contractions

and relaxations of the cell, and at the same time, with each recurrent oscillation, disposing the whole organism to a state of general tissue activity.

The administration of currents of high potential which flow between the terminals of the two opposite polarities certainly pass in narrow lines through the tissues to complete the circuit. The greater the potential or voltage of the current, the more direct will be these lines of passage between the two opposite polarities. The passage is comparable to a stream of water passing down a hillside or through a sandy plain. In one case, the channel will be very narrow and straight and only to a small degree saturate the banks, while the same stream, passing across a nearly level plain, will be tortuous and largely absorbed during its passage. This comparison would serve to indicate the different methods of passage of currents of high potential in comparison with the continuous current of low potential which is known to spread out through the tissues during its passage. One other observation in relation to these two types of current should be made, and that is that the current of low potential is disposed always to follow the tracks of best conduction, as the muscles or blood vessels of the body, while the currents of high-potential displacement-currents pass across and through tissues of slightly varying resistance in comparatively straight lines. The greater the quantity of the current passing, the greater will be the ionization or electrolytic action upon the tissues. This explains the very slight effects upon the tissues of the high-potential currents of small quantity which flow between two poles.

The mechanical effects of high-potential currents are the most valuable, we believe, from the therapeutic point of view, and may be exerted either directly or reflexly, according to the modality employed. The direct effects of these currents are derived from the conductive discharges, producing distinct muscular contraction and vibration, and undoubted contraction of cell protoplasm from their application. These effects from the conductive discharges are very largely local, being transmitted from the surface to a depth relative to the amplitude or *potential of delivery* of the current, which is varied by changing the length of the spark-gap.

The term potential of delivery is one which the author has adopted to express a condition of electrical discharges which should be defined, and for which there is no term in common use to designate. By it is meant the amplitude or spark length possible to deliver under the conditions of a circuit from a discharging electrode to the site of application. *The potential of delivery* will depend upon the length of the spark between the rods of the condensers, plus the potential added by a step-up transformer; the length of an effleuve of a convective character; or the length of spark-gap or the amplitude of the conductive discharges which are measured by the spark-gap. The size of the Leyden jars in the circuit of the current also varies the possibilities of the amplitude. The necessity for the employment of the term *potential of delivery* arises from the confusion that exists at this time with reference to the action of high-frequency and pulsatory currents. Too little attention has been paid to

the fact that when rapid interruptions are made in the circuit of a current pulsatory or oscillatory, that the periodicity is at the expense of the spark length possible if a brake is made in the circuit. Potential of discharge is shortened to produce a high rate. The spark discharging between the jars of the resonator of a high-frequency apparatus will be relative in rate to the length of the spark discharging, other things being equal. The length of a spark discharged from an electrode connected with the circuit will represent the *potential of delivery*. In other words, when administering a spark from a solenoid or Telsa coil or a combination of the two in connection with the outer coating of the two condensers of a static machine, a spark will be delivered relative to the length of the spark-gap, and of a rate of discharge increasing as the spark length is diminished or the rate of revolution of the plates of the machine is increased, plus an increase of potential developed in the solenoid. It will be seen, then, that the rate of interruption is increased at the expense of the *potential of delivery*. When, therefore, the fact is recognized that the intensity and the depth of perturbatory effect of a discharge depend upon its *potential of delivery*, and not upon the frequency of interruption, other things being equal, the importance of the designation and differential relations of potential and the rate of interruption can but be appreciated. The rate of interruption bears the same relation of inverse ratio to the potential of delivery in electrotherapeutics as speed does to power in mechanics. In the consideration of the mechanical effects of the elec-

trical discharges conductive, disruptive, or convective, the importance of the bearing of these considerations can be easily appreciated. *The mechanical effects of the currents of high frequency* except when painful in character, as are the sparks, or effleuve, and the possible action upon the cell due to the influence of the passage of an electrical current are considered, are otherwise practically nil. In other words, the currents of very high rates of interruption—pulsatory or oscillatory—are deficient in amplitude, do not produce muscular contraction, and are absolutely painless during administration. With them the potential of delivery is very small. The mechanical effects of such currents are therefore insignificant or of no value. The following conclusions as to the actions of high-potential discharges constitute a basis for their *mechanical* employment in therapeutics.

(1) *Currents derived from the static machine* have striking characteristics producing mechanical effects upon the tissues diffused, penetrating and painless, peculiar to these currents. When carried to the point of inducing tetanus, or when administered over inflammatory areas, their action may also become painful.

(2) *Secondary mechanical effects* are undoubtedly produced upon the tissues, which give tone to the muscular structures, and others probably of polarization.

(3) *Muscle and tissue contractions* are produced by all disruptive and convective discharges relative to their intensity or characteristics, and varying in penetration of delivery of the discharges,

Polarity. In the administration of the high-frequency currents—alternating in character—consideration of polarity does not enter. Such currents, as the designation implies, are alternately positive and negative at the two terminals of the circuit. This is objectionable, when it is a well-recognized fact that with unidirectional currents the local actions of the opposite polarities produce positively different effects.

In the local administrations of the wave-current in the treatment of acute inflammatory conditions, the writer has demonstrated repeatedly—often enough to establish the fact—that the wave-current derived from the negative side of the static machine when applied over such regions, while producing a *temporary* sedative effect, is followed after a short time by marked aggravation of a condition which had been improving. It has occurred in a sufficient number of instances during previous years when the polarity was looked upon as an indifferent factor to finally demonstrate the fact.

One well-marked instance will serve to illustrate the aggravating effect of the use of the wave-current connected directly to the negative side of the machine. A patient who had been treated for three days for an acute sciatica of a very severe type, in which the condition had been so greatly improved that he had slept the night previous to the fourth administration, was treated by an assistant. He connected the patient with the negative side of the machine, the positive being grounded, and administered the wave-current for the usual period of fifteen or twenty minutes. The patient left the office in a seemingly com-

fortable condition, without pain. On the following morning it was with difficulty that he could return to the office, requiring assistance to get on and off the cars and into the house for treatment. The wave-current was then applied in the usual manner connected with the positive side of the machine, after which the patient left the house with no vestige of pain or suffering and continued the course of his treatments for three days, when the recovery was complete. Similar results have occurred in other cases in which, with the use of the positive current, uniformly sedative results are obtained. It is the local action, especially in the treatment of inflammatory processes, where the polarity plays such an important part. It would also seem, and, so long experience has taught the writer, that the positive electrons exert a more favorable influence upon the general metabolism. Comparisons, however, of the two polarities have not been made as to the constitutional effects of the current, as the negative has been but little used in these conditions. From the positive, however, are always obtained desirable, sedative, and quieting effects which seem to indicate its employment, if not its choice, to the exclusion of the negative, for favorably affecting the nutritive processes of metabolism.

The application of the brush-discharge, with the patient connected to the negative side of the Holtz machine, is distinctly soothing to a painful and inflamed condition, as may be easily demonstrated. When a connection is made directly to the positive side, however, the effect is distinctly irritating. This is not only the effect at the time of an administration, but the writer has been con-

vinced after a series of experiments that an application with the patient attached to the positive side, will be followed by a recurrence of the symptoms a short time after the close of the administration, whereas, when the application is made with the patient connected to the negative side of the machine, the effects are soothing and sedative and the relief of the inflammatory process from a proper administration is prolonged, tending to the recovery of the condition. This unquestioned local action in connection with the administration of the brush-discharge proves clinically the certain indication for the choice for the connection of the patient with the *negative* pole during this form of administration.

With the vacuum tubes applied directly to the surface of the patient, the choice of polarity is to some extent an open question, but from recent results it seems to have been demonstrated that the connection made to the positive side of the Holtz machine is the choice for the treatment of local inflammatory conditions, where it is sought to allay the induration and restore an active metabolism. When the indications are for the treatment of local septic conditions, however, or where germs are present in the superficial tissues, the greater chemical action at the surface of the glass when connected with the negative side would indicate the connection with that side for the treatment of such conditions. In this connection it is well to state that the effects of muscular contractions are induced with a great deal more energy with the same length of spark-gap when the vacuum tube is connected with the positive side of the Holtz machine, than with the negative,

and also that greater energy is exerted when there is a leading-in wire in the electrode.

These effects suggest an important consideration of the actions of the electrons in their passage, but leave an element of doubt from the fact that when the brush-discharge is employed there is a passage by induction through and to the place of discharge of negative electrons, while with the wave-current the passage of the current surging to and fro is of positive electrons. In one instance the consideration is given entirely to the one polarity as it affects the surface during its escape, whereas, in the other instance, the opposite polarity produces the greater degree of sedative effect.

The explanation of these two opposite effects from different polarities is difficult to reconcile, and yet from clinical experience, which is the best proof, the truth is demonstrated in every instance where a careful study of the relative effects is made. So much of the action of these electrons upon the tissues is still unexplained, that the clinical results obtained may lead to final conclusions which may clear up or explain many of these actions.

The explanation of the differences of these effects must be made not from effects of the passage of the current, but probably from the irritating action of the positive discharges of the brush-discharge upon the end-organs, which is easily demonstrated by any observer.

From the therapeutic point of view, the importance of *muscular and cell contraction* and of vibration is of the greatest importance. The latter is so closely allied to muscular contraction as an effect that it is difficult to dis-

cover a distinct differentiation. It will be generally appreciated that most diseases arise from functional inactivities associated with *hyperæmia*, passive or active, and *congestive processes* induced by irritants which appear in the form of germs, the products of auto-infection, results of poor metabolism, or as the effects of traumatism. These conditions as stated are associated either with a degree of sluggish activity or with a condition of induration associated with local stasis.

In nature's method of walling off processes of infection, stasis is established and serves a valuable purpose, when infection is present. The same induration which is nature's *wall of safety* against the spread of infection is the greatest obstacle to recovery in other inflammatory affections. To relieve these conditions of local stasis or induration, which interfere with the restoration of normal circulation and ultimate absolute restitution, some energetic means is required. If the affected area is superficial, the application of a mechanical means will act as a *vis-a-tergo*, overcoming the induration, softening the tissues, and thereby restoring circulation and permitting the elimination of accumulated infiltration, and other products of an inflammation. It can but appeal to the mind of the intelligent reader that such a procedure is indicated before a normal restoration can follow.

Induration promptly follows trauma, as a sprain. The blood rapidly accumulates, and the tissues become hard, swollen, and indurated, with the ultimate establishment of what will become a chronic stiffening and impairment of the functions of the part. Thus, in consequence

of a shock sustained by the exposed tissues, dilatation of the capillaries and blood vessels, with the determination of an excessive quantity of blood to the part, becomes the first step towards the establishment of a chronic process. Nature has provided an increased blood-supply whenever an accident occurs in the tissues and repair is necessary. Under physiological conditions without the production of shock or severe injury, a compensatory supply of blood enlarges and develops the part, which is called into most energetic action; but if an accident occurs which results in an excessive supply for which there is not a corresponding demand, as above stated, swelling and induration result. For the removal of such a condition no compensatory action is provided, and local stasis, which will become a chronic inflammatory process, is established. The application of mechanical measures for the relief of local stasis, as it occurs either in association with trauma or infective processes, may be followed by prompt restoration. When, however, induration walls off cavities of infection where considerable pus is already present, to remove the induration would be to extend the infection.

While the application of other mechanical measures to conditions of stasis will induce circulatory drainage to a certain degree and re-establish to some extent the normal processes, their action is far less satisfactory than the application of the high-potential electrical currents; (1) because they do not produce contraction of the tissues to the extent that it is produced by an electrical current; (2) because the contraction induced by an external mechanical stimulus, not electrical, has not the same tend-

ency to preserve a prolonged state of contraction; (3) because the penetrating effect and diffuse action of the mechanical applications referred to are not such as to envelop and include all of the structures involved, and (4) their application is generally too painful in acute conditions to permit the production of complete relief of the local condition.

The *modus operandi* of the high-potential electrical applications of moderate rates of interruption, as applied to the treatment of acute congestion, is to stimulate the tissues to contraction, alternating with periods of relaxation. The induction of contraction, interrupted at intervals not too frequent, reduces a process of inflammation to normal. The flow of blood in the parts is thus restored and the activities of the lymphatics and end-organs which under pressure were in condition of stasis are restored.

It will be readily appreciated when an electrical stimulus is administered in the manner described, before much pus has formed in a commencing abscess, as of tonsilitis, felon, or carbuncle, it will overcome the local stasis, and at the same time increase the local leucocytosis and, causing more leucocytes to become phagocytes, will carry away the foci of infection and relieve a condition which would otherwise be followed by a painful process. This is undoubtedly the method of action, under a systematic application of the proper high-potential modalities to acute inflammatory processes.

In cases of trauma, as joint sprains, where no foci of infection are present, but a condition of injury to the soft parts, the effect of relieving the local congestion is all

that is required to relieve a process, which, if treated by other methods, will generally become chronic and be followed by months or years of suffering and inconvenience. When it is generally recognized that mechanical action is necessary to restore the normal circulation to an inflamed tissue; that its employment is the step of first importance for the relief of a non-infective or the early stage of an infected process; and that the action of high-potential discharges of low rates of interruption, which produce the effects of muscular and tissue contraction, are indicated, uncured non-infective, chronic inflammatory conditions will be rarely encountered.

In chronic conditions in which the early application of proper treatment has been delayed, the relief, while generally certain if persevered in, is not prompt because the products of inflammation have become more or less organized, and deposits of fibrin, and round-cell infiltration, and other products of inflammation, have become so extensive in the area that for their elimination a longer time will be required. Furthermore, when ankylosis is present, except in the superficial regions, little can be expected from the high-potential treatment unless the adhesions are first broken up, after which no means offer greater promise for subsequent relief and cure of chronic joint affections than the various applications of the high-potential currents and other modalities. In these cases, however, the long static sparks and wave-current administered with a very long spark-gap are requisite, because, in order to overcome the chronic induration, very penetrating effects are required. In the author's experience,

few joint affections where ankylosis or erosion has not occurred and no active germ process is present, will fail to respond to the systematic administration of high-potential electricity. In enlarged or congested glandular conditions resulting from poor metabolism, or the presence in the tissues of effete materials, substances that have not been eliminated, these high-potential currents are as a rule effective.

It is a recognized fact with those who are familiar with the uses of these modalities, that in glandular conditions, where hyperplasia or some organic destruction has not already taken place, it is possible by the mechanical action of these currents to restore in whole, or part, normal conditions, and that in cases in which an organic process of a slow inflammatory character is in progress, it is often possible to abate it, allay its progress, and remove the inflammatory exudates that are present, thereby largely improving the local conditions. This is notably true in prostatitis. In hypertrophic cirrhosis of the liver, chronic diffuse nephritis, chronic parenchymatous nephritis, in the early stages, and also in affections of the spleen, pancreas, and other glands of the body, the principles enunciated indicate their employment, and results obtained have demonstrated their utility.

The potential of delivery, in all cases, must be relative to the depth at which the lesion is seated, or the volume of the structure affected, and the results of their administration will depend upon the possibility of transmitting the electrical vibration and tissue contraction to the remotest part of the affected organ or region. This will de-

mand in many cases the administration of very long sparks, or the use of a very long spark-gap in connection with the conductive discharges. The modalities which partake of these qualities, producing muscular and tissue contraction, are the currents controlled to low rates of interruption, as the static wave-current and the static induced current, and the stimulating reflex effects of the direct sparks from the static machine and to a lesser degree the high-potential sparks from the resonator, or solenoid in connection with coil or static machine. The vacuum tubes, when employed in connection with the static machine, also produce distinct vibratory action and contraction, whereas, from coil sources the only effects of tissue contraction produced are those which are induced by the irritating effects of the discharges with the production of reflex contraction, without the distinct vibratory influence. It will be seen, therefore, that for the treatment of inflammatory conditions in which the intent of the administration is to produce circulatory drainage and local elimination, it is best stimulated by the induction of tissue contraction and local vibration, which are effected most energetically with the currents of lower rates of interruption and high potential.

Too much emphasis cannot be put upon the value of these mechanical effects of high-potential electricity, which have been generally ignored by writers in the past.

By the rational employment of these modalities it has been already demonstrated that numerous chronic conditions can be alleviated and the normal local circulation

and nutrition restored to the parts when other means have failed. When extensive septic processes are present, and deep-seated, the efforts to relieve them by the high-potential currents will be futile, because there is nothing in such discharges which is destructive to the cell, and consequently not to germ life, except in the superficial tissues, when the chemical effects of the discharges and the light may be applied in close enough relation to destroy them. It is only by increasing the general resistance of the body and by the stimulation of increased local leucocytosis, that it is possible to affect germ processes by these means when the discharges or the light influence cannot be brought in close contact with infected regions.

The antiseptic or germicidal action of the high-potential modalities is limited to the action locally of the effluve and the discharges surrounding the vacuum tubes when kept for a time in contact with the tissues as well as the chemical effects of the light produced within the vacuum tubes, and we may add, the cataphoric action of the high-potential discharges by which iodine and other antiseptic substances may be driven into the tissues. This action, however, is very slight, but deserving of consideration and further investigation.

The production of an oxidizing agent so active as ozone in proximity to the germ, insures a certain amount of destructive action. So also, the nitrous acid which is derived from the discharges is antiseptic in its action. It must be recognized, however, that the influence of these discharges is very superficial indeed, for the discharges always take place from the most superficial points of the

tissues and are also produced in the interval between the tissues and the vacuum tubes, or in the space between the surface and the other electrodes employed in the administration of the convective discharges.

It cannot be presumed that any spark discharges take place within the tissues of the patient, nor in any case has it been demonstrated, or can we believe, that the chemical effects of the discharges are conveyed beneath the surface. The extent of their action, therefore, is local and very limited, and to effect anything like a therapeutic result upon the integument or a mucous surface, the electrode, if a vacuum tube is employed, must be in close contact with the tissues.

The radiant energy of the cathode stream has an undoubted, though mild effect upon some forms of germ life. It has been shown that these radiations will penetrate the tissues to a considerable extent, and it has also been shown that the tubercle bacillus and gonococcus are susceptible to its influence, as also, we believe, are other germs. It is therefore, possible in the treatment of superficial conditions and processes in the cavities of the body where the vacuum tubes can be placed in close relation to congested or infected tissues, that a materially beneficial effect from the destruction of the germ life may result.

From the above observation it will be appreciated that a large range of indications for the application of high-potential modalities exists. In the subsequent chapters, details are given of their application to various special conditions.

CHAPTER X

SURGICAL CONDITIONS

WHEN it is recognized that all surgical procedures have to do with inflammatory conditions, the possibilities of these modalities are suggested. Their field, however, is limited, usually, to the preoperative conditions, where pus is not already present, or where absence of necrosis does not make necessary the removal of dead tissue, and not when malignant processes are to be treated either by operative procedures alone or in connection with the X-ray. In the latter conditions the use of these currents, if at all, will be postoperative.

For purpose of considering the employment of these currents, indications may be divided with reference to *simple* and *complicated* conditions.

Simple conditions. *Sprains* as they occur in the vicinity of joints are usually simple in character and not complicated with severe injuries of the soft parts or of the bones to which the ligaments are attached, and, therefore, a successful result is promptly obtained in most cases. If it is a recent case, within a few days after the injury a complete recovery can be assured, and in a time relative to the delay, the earlier cases yielding to two or three administrations. The application of the brush-discharge alone in these is usually all that is required. For those using the coil the resonator sparks will generally prove effect-

ive. If, however, when the patient comes under observation there is extensive swelling of the tissues and induration, the application of the wave-current, employing a tin or other soft metal electrode closely fitted to the surface for fifteen or twenty minutes, followed by an application of the brush-discharge, will greatly reduce the swelling, and relieve the induration at the first sitting more completely than if only the brush-discharge is employed. In chronic sprains, as in all conditions in which infiltration and deposits of fibrin have resulted, a vigorous application of sparks will hasten the recovery, inducing more rapidly reabsorption and elimination of these products of inflammation. If the most happy and prompt result is to be expected in those cases, they should always be treated daily. One treatment daily, however, will usually suffice. In severe early cases, however, the result will be more prompt if the treatments are administered daily for a day or two. The application should be made each time until the tissues are completely softened and the foot can be moved with but little pain. Under no circumstances advise the patient to rest the foot, but to go about as usual, unless the occupation is too active. In addition to the use of the brush-discharge the joint may be strapped or not. Strapping, however, precludes the possibility of a repetition of the accident and gives added confidence, but otherwise serves no purpose towards hastening the recovery, the real indication being the removal of local *stasis* and induration, the presence of which will be evidenced by the hardened and swollen condition of the part.

It was in the treatment of a patient who had fallen while exercising in a gymnasium, and had severely sprained the carpo-metacarpal articulation, that the writer was convinced for the first time of the remarkable effect of the brush-discharge upon local stasis. The patient came to the office within one-half hour after the accident, with his hand swollen to twice the normal thickness, and unable to close it. Examination, which was very painful, disclosed no injury or misplacement of the bony structures, but the hand was very much swollen and indurated. The brush-discharge was applied in the usual manner for ten or fifteen minutes, at the end of which time fully one-half of the swelling had disappeared, the tissues were softened, and the patient was able to completely close the hand without pain. Similar applications were made on the two following days, when the hand was in a normal condition, and continued so without pain on manipulation or use. This result, as suggested, depends on the usual principles of action—the *modus operandi* of the static modalities in the treatment of inflammatory conditions,—and given as a simple case illustrates a great principle, which is the fundamental idea upon which their employment is based in the treatment of such conditions. When the accident is recent, even when stasis is established, the restoration to normal is prompt because the products of inflammation have not escaped into the tissues, requiring reabsorption in order to restore the conditions to normal. It also demonstrates that the tissues, which have sustained a severe shock in which vascular dilatation has intervened, are left after an administration in a tonic

condition of contraction, thereby preventing a sudden relapse.

The same law is operative in the whole field of procedure against the ravages of inflammatory processes. It is *stasis* to be overcome, and the restoration to a normal circulatory and tonic condition in the tissues, that constitute the indications for first consideration in the treatment of all inflammatory conditions. The reabsorption and removal of the inflammatory exudates which have found a place in the tissues during the persistence of stasis in chronic processes must also be effected. Hyperplastic organized tissue will persist, resisting even these energetic modalities.

In all joint inflammations not characterized by the presence of pus, or a malignant, gonorrheal, or tubercular process, the prognosis for a complete recovery and restoration to normal conditions is excellent. In all such cases where ankylosis has not taken place or the lesion is not of more than two years' duration, systematic management assures success. Two years is not a positive limit, but about the average length of time in which structural changes take place, such as the absorption of the interarticular cartilage and the other ligamentous structures with the establishment of contractures of the muscular structures of the joint, which will render all but impossible a restoration of the parts to normal.

The fibrin, which is deposited upon the articular surfaces of joints which are fixed in a state of contraction, will limit the movement of the joint forward or backward. That this exudate may be relieved to some extent

by the movements of the joint during the period of improvement, and greatly assist the absorption induced by the application of sparks over the deposits, has been demonstrated in many cases which the writer has had under observation. It matters not what joint is affected, or what is the cause of the inflammatory process, noting the above exceptions, the treatment of these conditions is successful after the removal of the cause. The writer's cases include severe spinal injuries and injuries of all of the joints of the extremities, and conditions associated with or following rheumatism or rheumatoid arthritis, and the success in these cases has been uniform. After the first few weeks inflammatory products which have been thrown out demand, in addition to the more mild application of the wave-current and brush-discharge, that long direct sparks be applied both for the purpose of overcoming the muscular contractures and the relief of the deeper-located inflammatory tissues, as well as the local stimulation of metabolism to promote the reabsorption and removal of the exudates. It is unnecessary to speak more particularly of the different joint conditions, because the general rule of application is applied in all cases. The usual routine in chronic cases is the application of the static wave-current through metallic electrodes closely applied to the affected joint for twenty minutes daily, following each administration with the application of a sufficient number of long direct sparks to produce a relaxation of the contracted muscle and to relieve any local pain or tenderness in the joint which may persist after the administration of the current. The sparks should

always be applied freely over the soft structures of the joints, care being taken to avoid their application to the bony prominences, where they produce unnecessary pain and are not effective for the relief of any part of the inflammatory processes.

Dislocations after reduction should be treated in the same manner as sprains; the brush-discharge will, however, be all that is necessary for the relief of the condition if the reduction has taken place soon after the occurrence. The application will remove the swelling and greatly relieve the patient's condition if applied systematically for a few days, affording a degree of comfort which will be gratifying.

Contusion with or without abrasion may be greatly relieved and speedily cured by the application of the brush-discharge or resonator sparks, the latter from either coil or static machine. If the application is made immediately after the accident, no ecchymosis will appear, as the tissues will be immediately contracted and the hemorrhages into the tissues be promptly absorbed or prevented. If the characteristic *black* and *blue* appearance has appeared no measure will so promptly dissipate it, promoting its reabsorption, as the thorough application of the brush-discharge or resonator sparks applied about the eye or elsewhere. No restraint or care need be taken for fear of injuring the eye, as with the lid closed no accident or inconvenience can occur from the application. In cases in which abrasion has occurred, the application should generally be made around the margins of the abrasion. If applied directly over the abraded surface, it will

produce a degree of irritation which can as well be avoided. What is sought is the relief of the swelling and induration in the surrounding tissues, following external violence. The most remarkable results may be obtained from this application, relieving severe conditions. The healing which takes place when the parts are properly dressed will result in but slight scarring because the induration has been removed; for, as is well known, it is the induration that causes the thickening of the margin, producing the scar tissue which follows a contusion or the line of incision after an operation. The writer recalls a case of severe injury of the foot in which that member was swollen to about twice the natural size, and contused at two points, with ecchymosis extending from the toes back to within an inch or two of the heel, a heavy weight having fallen upon it. With treatment, this man, a laborer, was able to resume work within a week from the time of the injury and to walk within two days with but slight discomfort. The first application of the brush-discharge to this foot required forty minutes to soften the tissues, and at least half that time at each subsequent daily administration; the relief that was afforded, however, was ample reward for the time expended. Such results can be obtained, we believe, in no other manner, and probably the brush-discharge is better adapted for the treatment of these cases than any other modality. In lieu, however, of the static machine, the resonator sparks from a coil will be of great value. In these conditions the brush-discharge administered should always be of an interrupted type, two to three inches in length, and administered from

a stick which is kept considerably moistened on the surface. The application is painful and, as the tissues contract under the discharge, the patient will complain. For this reason, the application should be interrupted, moving it rapidly about over the surface, giving the part the benefit of short periods of rest, and should be applied until the tissues are thoroughly softened. The relief afforded and the prompt recovery is sufficient reward for the suffering endured by the patient during the administration.

The induration that forms along the *lines of sutures* after the dressing following an operation or injury, with pain, may be greatly relieved by the application of the brush-discharge, either through the dressing or directly to the uncovered skin. The relief from the pain in the line of the suture from this means is remarkable, and is a satisfaction to the physician and the patient.

When fractures occur in the vicinity of joints, the application of the brush-discharge is valuable. The wave-current and sparks are of doubtful efficacy in these cases, however, as they produce active muscular contraction, and are apt to separate the fragments of the fractured part. The brush-discharge, however, produces no such degree of contraction as will affect their relation and may be applied with energy and persistence until the tissues are thoroughly softened, affording great relief to the patient, and, when applied in the vicinity of the joints, persistently, throughout the course of repair, will preclude in a large measure the danger of ankylosis by preventing an extreme degree of congestion and the deposit of inflammatory products in and about the joint surfaces. This

modality can be administered either through plaster of Paris or wooden splints. When swelling associated with severe pain occurs after the application of bandages, great relief will follow the administration of the brush-discharge as above described.

Abscesses in the early stages before a pus cavity is established, such as felons (whitlows) or boils before much pus has developed, may be promptly aborted by the application of the brush-discharge over the commencing process. The application should be made interruptedly because the constant application produces so much pain that it is unbearable for the patient. It is surprising how thoroughly the induration of an abscess is dissipated during the first twenty-four hours of its existence, as indicated by the immediate cessation of pain and swelling.

The infection at this time is not considerable and is rapidly taken care of by the leucocytes and phagocytes, leaving the tissue in a perfectly normal condition, with no danger of carrying the infection elsewhere. Two or three applications will promptly relieve such conditions. The same results may be expected from the application of the brush-discharge over the induration externally, or to the tonsil, during the early stages of suppurative tonsilitis. The application in these cases should be made at the onset, when the success is uniform. The wave-current externally in these cases will, also, usually succeed, or a vacuum-tube may be applied—the one designed for application to the tonsil or tongue, shown in Fig. 14, placing it directly over the tonsil. The danger of producing gen-

eral infection in such cases is very small, indeed, unless the application is made after a pus cavity is already established. To break down the induration and throw the infection into the general circulation after a pus cavity is well established might prove a serious matter. For the same reason it is not wise to apply the brush-discharge or other means to remove induration around the margins of a carbuncle at the end of the suppurative stage, lest pus pockets might be in this way liberated into the general circulation. One case of this sort came under the writer's observation in the practice of an associate, in which the patient for several months was a sufferer from general septic infection. So in all conditions where nature's safe provision, the *wall of induration*, incloses infection, the process should not be interfered with by its removal, as can be easily done by the application of the wave-current or brush-discharge.

The above consideration of the method of employing these currents will suggest their application in a variety of surgical conditions, which will come under the observation of the physician and surgeon, and their value will be greatly appreciated by those who become familiar with their employment.

CHAPTER XI

AFFECTIONS OF THE GLANDS AND OTHER INTERNAL CONDITIONS

IN derangements of the large and small glands of the body the condition arises either from (1) excesses, (2) inactivity, or (3) irritating causes, and is inflammatory in character, either immediately before or after a demonstrative action intervenes. The indications for treatment are identically the same as for the treatment of other inflammatory processes.

Pressure from engorgement of the circulatory apparatus and other products of the process, obstruct and impair the functions of the glands involved, destroying the balance upon which the normal action of the organ depends. The institution of an inflammatory process in a gland with engorgement, also, produces obstruction of the tubules, establishing general stasis.

The gland structure is made up of tissues which are contractile in character, the muscular and yellow connective tissue constituting largely the structure of these organs. The application of any measure which will energetically induce recurrent contraction and relaxation of a gland thus involved will overcome this condition of functional and inflammatory stasis the same as in structures elsewhere, relieving both the arterial and venous engorgements, as well as expelling the contents of the gland, at the same time inducing functional activity of the gland.

When pus, germs, or necrosis are not present, or organic changes have not intervened to impair the normal function of the organ, the prognosis is always good. The general principles governing the administration of the high-potential modalities are rational, and their efficacy has been demonstrated in so many conditions that there can be no doubt of their great superiority to the uncertain action of the medical remedies usually prescribed for the relief of such conditions. The high-potential currents act by inducing recurrent contraction and relaxation, forcing the structures of the organ to take on activity, inducing a circulatory drainage and expulsion of the contents of the glands, and at the same time restoring a condition of functional activity and tonic contraction where relaxed and dilated vessels were present, thereby promoting a rapid restoration of the organ to a normal condition. The value of the application of the high-potential modalities to the treatment of inflammatory conditions, except those the seat of necrosis, suppuration, or other germ processes, is established beyond question or controversy. It will be necessary only in a casual way to refer to some of these affections, which have been treated fully in the previous work by the author,* but for purposes of classification.

The process of stasis arising also from inactivity of function, inducing finally a passive hyperæmia of the part and relaxed conditions terminating in a degenerative process, is the least common of all of the cases for consideration, and only arises in those patients who, either by

* "Electro-Static Modes of Application, Therapeutics, Radiography, and Radiotherapy."

habit or circumstance, are so placed that proper exercise and use of the organism is not observed. In most of these cases, as well, there is a disposition to excessive feeding, and overloading of the system, which aggravates the conditions of functional inactivity. In these cases the indication is to begin with the institution of a proper regimen in the way of exercise, together with the systematic employment of the high-potential electrical currents, which will greatly assist in inducing a general recuperation and return of the normal activities.

The static wave-current applied directly over inactive organs or glands, employing on general principles as large a dispersing electrode as can be used and still produce a distinct vibratory action over the abdominal viscera, particularly over the liver, pancreas, stomach, and the solar and hepatic plexuses, will offer more for the rapid restoration of these patients to normal function than any other electrical modality known to the writer.

The employment of auto-condensation in the treatment of constitutional affections is advocated by many able authorities, and is certainly worthy of thoughtful consideration and may prove of inestimable value. The diversity of opinion existing, however, as to their action, does not seem to indicate a great degree of efficiency.

The associated employment of light baths, mechanical vibration, regulated diet, and systematic exercise will complete the requirements and prompt restoration follow their use in all cases where organic changes have not intervened.

Excess, with all that it implies, is one of the most pro-

lific causes of the disturbances of the glandular and organic systems. Abuse of the various functions as well as the excessive inception of foods, and the employment of alcoholic beverages, are the most common causes of disease.

Engorgement of the liver is one of the most common of the conditions present and is more or less constant in a large class of patients, associated often in later life by the establishment of general arterial sclerosis, with its train of affections associated with the heart, kidneys, as well as other glandular structures. Wherever these conditions arise, the indication for an early removal of the cause by a regulation of the habits, exercise, and diet, and the systematic application of the static wave-current, which will promote normal activity of the glandular structures, is apparent. By such means the general engorgement is relieved, an active elimination induced, and coincidentally the normal functions of the organ are restored. Probably no measure that can be applied locally is more rational in its action or more energetic for this purpose than the wave-current. In some cases with obese, muscular, and heavily built patients, the additional application of long, indirect sparks over the parts may be necessary unless a very powerful static machine is employed.

In the conditions arising from arterio-sclerosis the employment of arc-light baths and the wave-current, together with careful regulation of habit, will anticipate an unfortunate climax in most cases. *In the advanced cases* of arterio-sclerosis, however, the probabilities of

relieving the degenerated conditions of the muscular coat of the arterioles are beyond hope or possibility. That the associated conditions may be greatly relieved, however, by systematic treatment is undoubtedly proved, as in the successful employment of the wave-current over the kidneys in cases of chronic nephritis. The action is compensatory and productive of marked influences, but in these cases it should be employed in connection with arc-light baths and the application of the static spray or brush-discharge over the surface of the patient, which by increasing the capillary circulation in the skin will greatly relieve the internal congested conditions.

The treatment of *arterio-sclerosis* should, therefore, include the use of the static wave-current, employing a very short spark-gap with short sittings, the use of the convective discharges applied thoroughly over the trunk of the patient, and administrations of the arc-light bath. The too stimulating employment of the wave-current in these cases is apt to induce an apoplectic attack by inducing increased force of the heart's action against the weakened arterial walls. Fifteen minutes' application, employing a spark-gap two inches in length, may be considered sufficient in most cases. The previous use of the light-bath, which brings the blood largely into the skin, will relieve the liability of danger from this application. In these cases the administration, superficially, of the effleuve or brush-discharge thoroughly to the surface of the body, producing a hyperæmia of the skin, greatly assists in relieving the arterial tension. True angina pectoris has been so remarkably relieved by this method,

in conjunction with arc-light baths, as to give it a prominent place as a recognized means for the treatment of this distressing condition.

The various affections arising from excesses in which these methods of treatment are indicated would include diabetes (acute and chronic), Bright's disease, cirrhosis of the liver, derangement of the functions of secretion and excretion in the alimentary canal, and allied conditions. In all of these the indication for treatment is the application of the wave-current daily for twenty minutes with a proper electrode as nearly in contact with the affected organs as possible, employing a spark-gap in all cases, except where arterial sclerosis is advanced, as long as can be administered without producing unpleasant muscular contraction or pain due to the contraction of the tissues of the congested organ. The prognosis in all cases will depend upon the extent of the organic or structural changes in the gland and the circulatory apparatus upon which its blood supply depends.

The presence of germs and other irritants affecting the glandular apparatus requires measures additional to the high-potential currents for their relief. The employment, however, of the resonator spark in connection with the X-ray for the treatment of *tuberculosis of the lymphatic glands* is certainly remarkably efficacious and the treatment *par excellence*, if a suppurative process has not already intervened. It is possible that the successful result is brought about in these cases by increasing the resistance of the tissues, and thereby getting rid of the tubercular process.

Affections of the ductless glands. In Graves' disease and Addison's disease, the pathology of which is so little understood except it is to be presumed that the early stage of the process must be either an inflammatory one or due to some functional derangement, either in the central nervous system or in the gland, the indications then are direct application to the structure of the gland affected or the employment of some means which will accelerate functional activity, restoring the general normal metabolism. It has been shown by Dr. Edward Titus that these applications do relieve such conditions, as has been shown by the treatment of an isolated case of Addison's disease. The wave-current in that case was applied over the region of the liver and the abdominal plexuses. A remarkable change took place in the condition of the patient. He gained fifteen pounds in body weight in six weeks, with marked disappearance of the discoloration of the skin. It is to be regretted that this patient died a few months later from pneumonia, or a more complete study of the case might have been made.

Success in the treatment of exophthalmic goiter has been extraordinary in the hands of various observers. The indication is the application of the wave-current directly to the gland and over the upper part and cervical region, followed by another application with a long spinal electrode over the spine for the usual time. The effects upon the tachycardia in some cases is striking. In other cases the relief following the treatment is not so marked. If the cases come under observation in the early stage, success is the rule.

In the treatment of hypertrophic cirrhosis of the liver, the wave-current, when applied directly over the enlarged and engorged organ, tends to its rapid disgorgement. The result in cases under observation has been very satisfactory, the gland being reduced to about the normal size; the general health and condition of the patient indicating recovery. Unfortunately, in these patients, however, the alcohol habit is the most difficult to cure, and the prognosis will depend as much upon the habits of the patient as upon the method of treatment, which, though it may abate from time to time the exacerbations as they arise, will effect a cure only in cases that come under observation early and in those who are willing to abstain absolutely from the use of alcohol.

The scope of this work permits but a discussion of the general principles which govern the action of the currents. The judgment of the physician will enable him to meet the indications, observing the general principles of administration. The writer, in his previous work, has given an outline for the treatment of special conditions.

There are various other conditions for which these modalities are indicated, along the same lines of the general principles of action as indicated in special cases referred to.

In diseases of the stomach, probably there are no better means of affecting the secretions and relaxed atonic conditions than the high-potential electrical currents. It has been the custom in the past to employ the continuous (galvanic) current directly within the organ. We believe that all that is necessary in most cases is the application

directly over the stomach of high-potential modalities, which will restore tone by actively stimulating the organ, at the same time affecting the duodenum, liver, pancreas, and other organs upon which the function of digestion depends. The conditions in which these modalities are

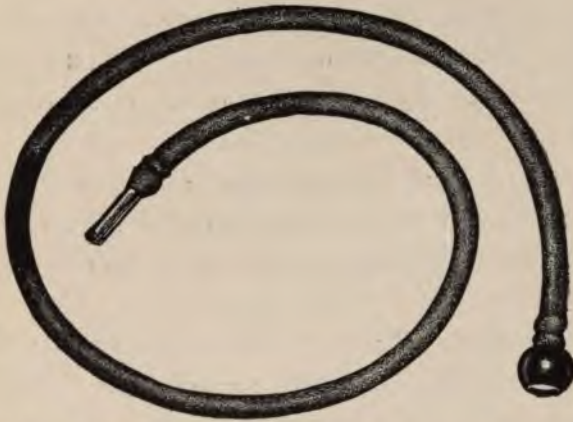


FIG. 19. Intra-gastric Electrode for High-potential Currents
(Waite & Bartlett).

invaluable are myasthenia gastrica, dilatation, gastrop-tosis, ulcers, and all functional derangements by which the activity of the organ is impaired. In catarrhal conditions the action will be far less effective, though by improving a general functional activity it may be possible in many cases to throw off the process and in a measure compensate for the associated impaired digestion.

The intra-gastric administration of high-potential currents as suggested by Dr. Harvey H. Roberts, of Lexington, Ky., by means of an electrode which he has designed, which is shown in Fig. 19, is effective for internal stimu-

lation, and if applied systematically may also affect a catarrhal condition present in the interior of the organ.

The administration of the wave-current and sparks, applied directly over the organ, are the modalities usually employed in the treatment of gastric conditions.

In ulcer of the stomach, the application of the wave-current over the epigastrium will overcome the margin of stasis or induration surrounding the ulcer and promote its healing, as in cases of *ulcers of the colon* referred to elsewhere.

The judicious use of the X-ray in connection with the wave-current, in various catarrhal and congested conditions of the abdominal viscera, is a valuable aid and worthy of thoughtful consideration.

In tuberculosis, the application of currents of high frequency and high potential, and of high potential and other frequencies, are means which offer much for the restoration or improvement of metabolism, thereby increasing the general resistance of the patient and promoting a return to health. The success of Chisholm Williams, Riviere, and others in the treatment of tuberculosis by the high-frequency currents, employing the auto-condensation method, is one of the strongest arguments in favor of that *modus operandi*. Similar results by Dr. Barton of New York in the treatment of these cases by the employment of high-potential alternating currents of large amperage by a special apparatus are also deserving of mention. He employs the current as shown in Fig. 16. The patient is seated before the apparatus, holding in one hand a metal electrode connected to one side of the high-frequency ap-

paratus, while the operator applies the other—a glass vacuum electrode—thoroughly over the chest anteriorly and posteriorly. That the action produces the same effect is evidenced from the reaction that occurs following the first treatments. A suitable vacuum tube may be applied over the chest in the same manner from a static machine without the second electrode in the patient's hands, the circuit being completed by induction or conduction through the floor of the room.

CHAPTER XII

NERVOUS DISEASES

THE scope of this work will not permit the consideration of the therapeutics of nervous diseases except in a general way. The author in his previous work,* however, has elaborated on methods applicable to the treatment of numerous affections of the nervous system, to which the reader is referred. As has been said previously in these chapters, there are few diseases that do not partake of the characteristics of inflammatory processes. In this statement are included the diseases of the nervous system.

The two types of hyperæmia—acute and passive—lead to impairment of function, which in the nervous system is particularly apt to be followed by degeneration, loss of functionation, and various other effects.

Lesions of the brain are practically beyond relief from applications of the high-potential currents, because it is impossible to pass these currents effectively through the bony structure of the skull, and because pain on application over the scalp, with the hair removed, only permits the shortest spark-gap with the wave-current. In so far, however, as the improvement of general metabolism and changes in arterial tension from administrations else-

* "Electro-Static Modes of Application, Therapeutics, and the Uses of the Roentgen Ray."

where offer relief, they are indicated in these conditions.

Lesions of the cord and peripheral nervous system, however, are not more amenable to any other method of treatment than to the high-potential currents, and no other measure known to medical science can relieve so generally inflammatory conditions as the high-potential electrical modalities.

Authorities who have failed to appreciate this truth are not aware of the character of the action of high-potential electricity upon the processes of congestion, which is to be regretted, for the mass of the profession are certain to follow these leaders and neglect for years what is certain to become in the future a recognized and valued treatment for most if not all inflammatory conditions of the cord and peripheral nervous system.

When it is recognized that there is a means for coping with such conditions and that the high-potential electrical currents do relieve *local stasis* and promote active local metabolism, thereby repairing conditions which have become congested from injury, passive hyperæmia, or other degeneration process, their adoption will become universal, and supplant methods less efficient, in vogue at the present time. It is so often said to-day in treatises on nervous diseases that wherever a condition resists simpler measures, "*on general principles give the patient potassium iodide or mixed treatment.*" The tendency of the neurologist is to fall back upon syphilis as the probable source of most incurable nervous diseases, which is deplorable. This practice generally results in absolute

failure and an added derangement of digestion, whereas, if the more probable hypothesis was acted upon that these conditions arise from slight derangements which induce conditions of local stasis and become the center of chronic inflammatory processes with no tendency to abate, and proper means were adopted to overcome stasis and restore normal circulatory and functional activity to the parts, chronic diseases of the spinal cord and peripheral nervous system with their dire results, when observed early, would be generally abated. As has been previously stated, there is no measure so active in overcoming these conditions of local congestion, with the institution of prompt repair, as the high-potential electrical modalities rationally applied. It matters not whether the case in question is one of *early* tabes, myelitis, or neuritis, the prognosis is the same, and ultimate complete restoration the result.

The application of high-potential electricity to diseases of the spinal cord, to be successful, calls for a knowledge of the necessary degree of potential which, judiciously expended, will penetrate the deepest structures of the region. The administration of the wave-current over the muscles of the back will effectively overcome the deep congestions present when applied with the energy of the modern Holtz machine. A sixteen-plate Holtz machine in any case, and one having but eight revolving plates in most cases, will produce a degree of vibration and tissue contraction which will penetrate the muscular structures and most dense fibers of the human frame with sufficient energy to favorably affect a congestive process in the re-

cesses of the spinal cord as no other known means in the hands of the profession to-day. The administration of large doses of strychnine or iodide of potash, by no law of analogy or understanding of the action of these drugs, would favorably affect simple congestive processes of the spinal cord. It would be as rational to give large doses of strychnine for the relief of acute sciatica as for the relief of tabes or other maladies of the cord. The number who maintain that locomotor ataxia has its origin in syphilis, and that there is an indication in such cases for the employment of such treatment, is gradually becoming less; and already there is a disposition on the part of some neurologists to adopt the static method, while others are employing large doses of iodide of potash or strychnine. Undoubtedly these conditions of the cord, as well as most of the traumatic conditions, are due to one or another type by hyperæmia or active congestion progressing to the destruction of cells and the substitution of sclerotic tissue.

The author's success in the treatment of tabes has led to a different conception in his mind as to the prognosis of this terrible malady. With the improvement of the local cord affections derived from the powerful application of the static wave-current and long percussion sparks over the cord, together with the associated administration of peripheral stimulation by the application of friction sparks, there are very few cases of tabes which cannot be brought to a *statu quo* and greatly benefited and even cured in the incipient stages. The application of the same modalities to myelitis and traumatic injuries

of the spine and the dystrophies is followed with like good results.

In cases of local neuritis when the site of the lesion has been localized, the application of the static wave-current and sparks directly to the site of the inflammatory process will positively result in the cure of every uncomplicated case, acute or chronic. The time necessary to effect this result varies from a few days in the early stages to a few months after the establishment of chronic conditions, arising from the inflammatory process. During the past six years the author has cured every case of acute sciatica which came under his care (thirty) within ten days.

It will never be possible under any circumstances to restore neurons that are destroyed. The relief, however, of an inflammatory process will undoubtedly restore to activity many neurons whose activity has been rendered dormant by a congestive process.

The peripheral impressions are dependent upon the release of the central neurons and the improved general activity of local metabolism.

The methods of administration of the high-potential electrical modalities to congested conditions of the nervous system are the same as in other inflammatory processes. The *prognosis* is relative to the chronicity and accessibility of the structures involved, as well as to the *modus operandi* employed. *The potential of delivery*—length of wave-current spark-gap, or of the spark administered—must be relative to the density or limitations of the parts affected. When it is fully realized, as it will be by all in the future, that these high-

potential modalities under systematic application possess no irritating qualities but are a sedative, because inflammation is allayed and the tissues are left in a state of local activity and tonicity following the administration, and that in no sense do they institute but relieve congestive processes, the value and indication for their administration will be recognized. Those who do not employ these currents in diseases of the nervous system are not cognizant of the character of their action, or the general prognosis would be more encouraging.

It is not the purpose in this chapter to go farther than to emphasize the importance of the high-potential methods in the treatment of nervous disorders. It will be appreciated, however, that the scope of indication not only includes the local inflammatory affections of the nervous system, but all functional neuroses arising from local inflammatory processes in the other organs and structures of the body. It will be found by all who intelligently employ these modalities in the treatment of nervous diseases, that conditions which are often ranked as incurable will many of them be found to yield.

CHAPTER XIII

TREATMENT OF DISEASES OF THE RECTUM, SIGMOID, AND GENITO-URINARY APPARATUS

THE general principles of treatment applied to the above conditions call for an unusual amount of skill and tact and are not followed by a large measure of success by ordinary methods. They are, however, particularly amenable to the electrical forms of treatment. The same general principles appertain to the treatment of these cases as in the treatment of induration elsewhere.

The induration which surrounds an ulcer is the occasion of the chronicity of the condition, and if the surface alone is stimulated by caustic or local stimulants, it will usually be impossible to bring about a rapid healing of the ulcer. Furthermore, all ulcers finally healed in the presence of surrounding induration in the structures under consideration are certain to result in contractions consisting of scar tissue, which narrow the canal and constitute the structure of organized strictures—a subsequent source of annoyance and inconvenience to the patient.

The particular advantage from the treatment of these conditions by electrical methods lies in the fact that the healing is promoted by the removal of the induration. A current or other modality mechanically produces during the administration tissue contraction alternating with

intervals of relaxation and vibration, which is stimulated either through an electrode in contact with the surface surrounding the ulcer, or by the systematic administration of an effluve or brush-discharge. The induration is thus removed and the blood permitted to circulate to the margins of an ulcer, promoting rapid healing even under



FIG. 20. Author's First Type of Rectal Electrodes.

the unfavorable circumstance of location in a cavity which is irritated by daily passages of faecal matter. It is necessary, however, in order to treat an ulcerated surface thoroughly, and to remove the induration surrounding the whole ulcer in closed cavities where the mucous membrane folds in upon itself, to make the application with a properly adapted electrode, which will spread out the folds of the mucous membrane. Special electrodes have accordingly been designed for treatment of the rectum and sigmoid. Those shown in three sizes (Fig. 20) were the first ones designed by the writer for treat-

ment of rectal ulcers and fissures of the anus. They are too small, however, to treat any considerable ulceration in the rectum, as there would be no certainty of the electrode coming into proper contact with the surface of an ulcer. It is better adapted to the treatment of small ulcers in the lower end of the sigmoid. The three electrodes shown in Fig. 21 have a curved extremity designed to be carried up into the tortuous sigmoid for administra-



FIG. 21. Rectal Electrodes Designed to Reach the Sigmoid.

tions higher up, and others may be especially designed for application to special cases. The electrode shown in Fig. 22 is larger and made of heavy glass, for passage into the rectum for the treatment of ulcerations in the lower portion. It will distend the mucous membrane, thereby bringing the surface of the ulceration into closer and more certain contact with the surface of the electrode.

Another practical method of making the application to the ulcerations of the rectum and sigmoid is by the use

of a speculum or proctoscope. Having located the ulcer, a vacuum tube, provided with insulation to prevent the escape of the current, is passed through the speculum and placed in contact with the surface, or this may be done



FIG. 22. Large Rectal Vacuum Electrode.

successfully and with less discomfort by the guiding finger of the operator. The electrode used for the tongue and tonsil (see Fig. 23) serves well for this purpose. If specula are employed, those of glass or rubber may be selected, when it will not be necessary to use an insulated vacuum tube. By the employment of these means and



FIG. 23. Vacuum Electrode Designed for Treatment of Tongue or Tonsil.

methods, it will be readily seen that direct application can be made to ulcerated surfaces, and healing will be effected in a satisfactory and expeditious manner.

The importance of removing all of the induration surrounding an ulcer, and thereby preventing the development of scar tissue, must be recognized. To accomplish this, the electrode should be made large enough to entirely cover the area of induration surrounding it. This is a matter of considerable importance in the treatment of

rectal ulcers, as it will prevent the development of strictures—one of the causes of chronic constipation.

It will be difficult in many cases to carry the vacuum tubes high enough into the sigmoid to overcome ulcerations of the colon above. In these cases success will usually follow the application of the wave-current over the region above the pubis. Ulcers simple in character, in the abdominal cavity, are successfully treated by placing an electrode of metal over the region and pressing it deeply over the ulcer, employing the wave-current with as long a spark-gap as can be borne without contracting the muscles or causing too much pain. Wherever it is possible to diagnose and locate a simple ulcer, the healing is assured if the treatment is thorough. When it is situated above the rectum and cannot be treated by the internal application, the external administration of the wave-current as above described will in most cases successfully remove the induration and heal the ulcer.

Stricture of the rectum cannot be treated successfully by the high-potential currents. The continuous current (negative pole), however, is well adapted for the absorption of scar tissue and will relieve these cases. They have been treated under the author's observation and the lumen greatly enlarged.

Constipation arising from spasmodic contraction of the sphincter ani or other contractions in the rectum or sigmoid may be successfully treated by the employment of the static wave-current, using day after day larger sizes of rectal electrodes (which may be designed for special cases) or by the use of the vacuum tubes attached directly

to the negative side of the static machine, or any other current source which will produce muscular contraction. It is well to employ larger tubes as treatment progresses. This condition is generally more successfully treated, however, by the employment of mechanical vibration over the abdomen, and by the internal use of long flexible rectal vibratodes.

If electricity is to be employed in the treatment of constipation, a metal electrode five-eighths to three-fourths



FIG. 24. Rectal Electrode Set for Use with Patient in Sitting Posture.
1, 2 and 3, Variety of Electrodes; A, Insulated Portion.

of an inch in diameter should be passed into the rectum. It may be accomplished by the patient sitting with the author's especially designed electrode in the rectum (see Fig. 24) or administered to the patient lying on the side. The patient may then hold a straight rectal (Fig. 26) electrode in position with one hand, with a small pillow placed beneath the hand for support, as in the treatment of prostatitis. The electrode may instead be held in position by screwing an insulated handle to the electrode and securing it in position with the ordinary X-ray tube holder, as shown in the Frontispiece or Plate VIII. The

tube holder may be employed in this manner for holding electrodes in position when treating prostatitis and affections of the uterus and vagina. It will be found a very convenient method, permitting the operator to be otherwise engaged instead of holding it in position.

The wave-current may be employed in the treatment of constipation, when as long a spark-gap should be used as can be tolerated without discomfort for fifteen minutes, at the end of which time make use of the swelling current, by the method described by Dr. Sigismund Cohn. This is accomplished without otherwise changing the connections. Either push the discharging rod on the grounded side rapidly in and out, allowing the passage of as long sparks as the machine will produce, and then closing it to zero, or when possible, as with some types of machines, loosen the set screw which holds the discharging rod in a horizontal position and cause the handle to rise and fall, passing near the ball of the opposite side with each movement, for a period of five minutes. Another method is the employment of the *static induced current* with a large metal plate over the abdomen, and the electrode as employed with the wave-current in the rectum (see Frontispiece). Administer the current for fifteen minutes with as large a spark-gap as can be tolerated without discomfort, and at the close of this part of the administration for five minutes, at short intervals, interrupt the current by moving the rod for connecting the outer sides of the Leyden jars, opening and closing the connection. It will be necessary, when performing this last maneuver, to make the spark-gap somewhat shorter than during the first

part of the administration, as an unpleasant degree of contraction will otherwise be induced. A positive contraction, but not too severe, of the abdominal muscles is desirable.

The treatment of constipation by high-potential currents, while satisfactory, in lieu of better methods, will seldom be resorted to by those who have the mechanical vibration apparatus and are familiar with the method. (See "Mechanical Vibration," by Dr. M. L. H. Arnold Snow, pages 224 to 230.) That method, associated with correction of habit and diet, is far more successful than any other, with which we are familiar, in overcoming constipation.

The indications in prolapse of the rectum are: (1) the relief of constipation, which is the usual cause of the condition, (2) the restoration of tone to the mucous membrane, and (3) the removal of polypi when present. Relaxed conditions are greatly relieved by the employment either of larger-sized rectal vacuum tubes or a large metal electrode placed within the rectum.

Fissure of the anus. The treatment of this distressing condition is one of the oldest and classical triumphs of so-called "*high-frequency currents*," and was first employed and advocated by the French. The operative procedures, and the painful process of forcible dilatation, which are the recognized methods, will be entirely supplanted by this painless and uniformly successful means by members of the profession who have the facilities, and the public will soon demand it. The *modus operandi* is of the simplest character, the cure resulting from the two

effects of, (1) relief of the local induration surrounding the fissures, and (2) the stimulating action of the discharges from the vacuum tubes. During the course of treatment, the patient's bowels should be kept moderately loose for, at least, a week or ten days, and daily application for ten minutes should be made with the smallest hemorrhoidal vacuum tube (Fig. 25), employed preferably in direct connection with the static machine. The electrode may be inserted as far as the bulbous portion,



FIG. 25. Dr. Arnold Snow's Hemorrhoidal Vacuum Electrodes. Three Sizes

or it may be done successfully if only the first inch of the tube is employed. The relief immediately after the administration of the current is remarkable and success is assured in every case, requiring usually from ten days to two weeks to complete the cure. One advantage of this plan of treatment is that the removal of induration insures healing without the presence of scar tissue. Con-

sequently there is very little danger of recurrence of the trouble from subsequent rupture, which is apt to occur after treatment by other methods. Following the treatment of fissures, if a spasmodic habit of the anal muscle persists, it should be treated for ten to twenty minutes daily, employing electrodes of the hemorrhoidal type, of glass or metal (Fig. 25), gradually increasing the size to about one inch in diameter.

Hemorrhoids as they occur in association with impaired action of the liver and constipation, in their early stages, are easily cured by the removal of the causes and the treatment of the local condition.

Congested conditions of the liver are most remarkably relieved by the application of the static wave-current by using a large sheet-metal electrode over the anterior of the liver and extending across the epigastrium. An electrode, four to six by ten or twelve inches, is placed in position and the current administered, as usual, from the positive side of the machine and continued for about twenty minutes daily. The spark-gap will vary from four to twelve inches, depending upon the extent of vibration or muscular contraction produced. This will depend upon the physical condition of the patient, and the application made should not be painful or severe. The administration lessens the local congestion after a time, relative as a rule to the chronicity of the trouble, and thereby removes, to some extent, the obstruction of the blood-flow through the hemorrhoidal veins. The treatment of constipation, as considered above, will relieve the other causative conditions of hemorrhoids. The local treat-

ment of hemorrhoids will result in a complete or partial relief, relative to the chronicity of the hemorrhoidal condition. The early cases, and many others, are promptly relieved and cured, and all cases materially benefited. In some cases, however, it may be necessary to resort either to the employment of the positive pole of the continuous-current, surgical procedures, or some injection method. The objection when the clamp and cautery or ligature are employed in these cases, is the almost certain production of scar tissue, with a consequent narrowing of the canal. If the clamp and cautery or ligature are employed, however, high-potential electricity with the vacuum tubes, if applied for ten minutes daily, beginning about five days after the operation, will largely relieve the induration and lessen the production of scar tissue. This method should be employed after the surgical treatment of the condition, also after the pile has separated, following the application of positive galvanism or the injection method. The small ulcer remaining will be stimulated to rapid healing by daily applications of the vacuum tubes and no farther trouble will result.

Prostatitis, as treated and cured by high-potential electrical currents, is one of the greatest advances of modern treatment. When the method, as hereafter described, is thoroughly understood and appreciated, and a diagnosis made relatively early, few cases of prostatitis, except the malignant and tubercular cases, are likely to require surgical treatment.

Prostatitis is one of the most accessible conditions for making direct application, and is, therefore, one of the

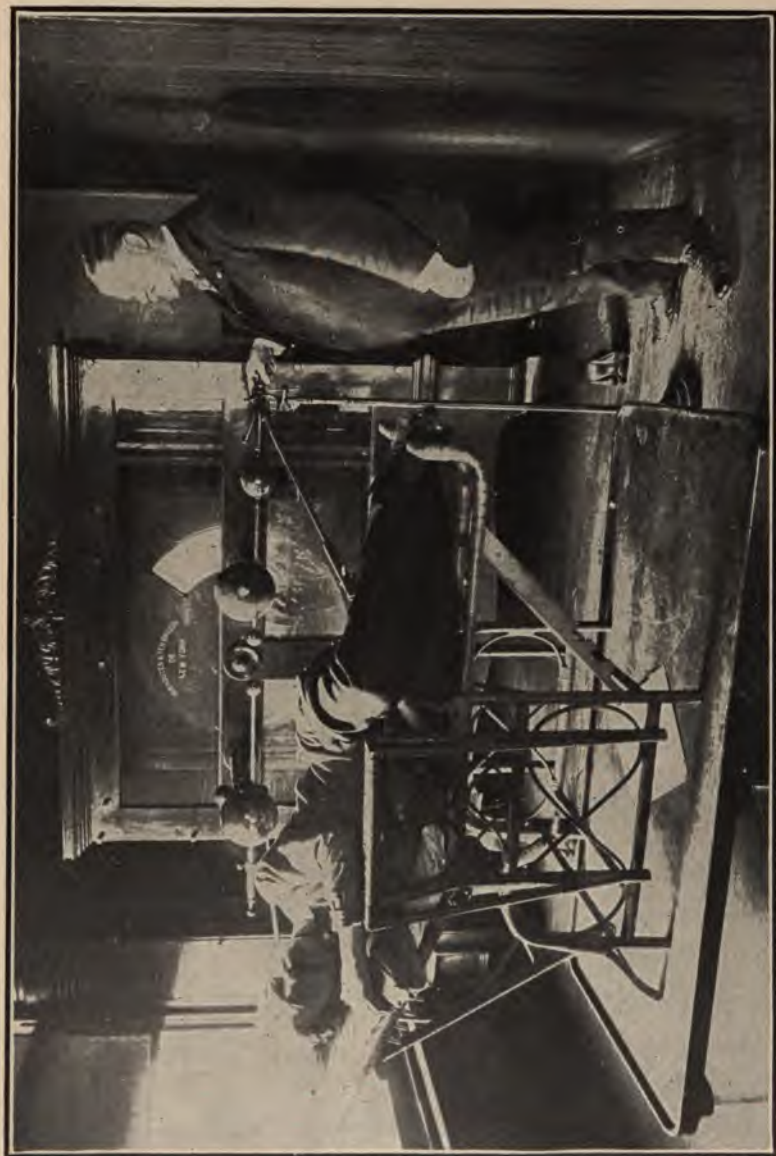


PLATE VIII. Showing Method of Holding Rectal Electrode during Administration of the Wave-current.

most amenable of all congested processes to this method of treatment. The static wave-current, and the employment of other high-potential currents with the properly shaped vacuum electrodes, are both successful in the treatment. The writer, however, prefers the static wave-current because he finds it to be the most effective. The method of treatment employed consists in applying a metal electrode in the rectum in close contact with the prostate gland. This is accomplished with comfort to the patient lying upon pillows or a blanket placed upon the insulated platform, or preferably upon a wooden operating table or static chair, which is also placed upon the insulated platform. A small pillow to support the hand of the patient, if he holds the electrode in position, will be appreciated. He should press backward on the handle, holding the electrode firmly (not too firmly) against the gland. The employment of an X-ray tube holder—screwing the handle of the electrode with the clamp as shown in Plate VIII—is a very convenient method of holding it in proper position during the administration. The same plan is applicable for retaining vacuum tubes and other electrodes in position in the various cavities of the body. It should be borne in mind, however, that wood is a conductor of high-potential currents (particularly the static) and the handle of the metal electrode, therefore, should be of vulcanite, glass, or some other non-conducting material, to be held in position with the tube holder, lest enough of the current escape to prevent the possibility of obtaining the desirable length of spark-gap. The current employed should have sufficient po-

tential of delivery to relieve the condition. It is a well-known fact that the escape of considerable current makes impossible the restraint of sufficient potential to produce a long spark at the spark-gap with the wave-current. The electrode should be first placed in position and the machine then started at a moderate rate of speed; the operator will then gradually draw out one of the discharging rods (the grounded one that he may avoid getting sparks to his hand) until the patient feels a sense of discomfort, either from the fact that too much pain is caused by contraction of the tissues of the structures of the gland, or that the contractions of the long muscles become too severe, or tonic in character. The sensation will be painful with a length of spark-gap relative to the degree of congestion. In a subacute, inflammatory process, a distinct vibratory sensation will be produced with but little pain. In the instance of an active congestion, the spark-gap will be opened but a short distance before the patient will protest on account of the pain produced. As the pain diminishes—which it will—the operator should, from time to time, gradually draw out one of the discharging rods, following exactly the same tactics as in the treatment of acute sciatica and other inflammatory conditions.

The sense of relief that follows the first administrations is remarkable and a source of gratification to the patient. Cases of prostatitis of four or five years' standing have been completely cured by the writer by this method in from three to six weeks,—conditions which have defied massage and other methods of treatment.

Seminal vesiculitis, so commonly present, is relieved

coincidentally to the treatment of prostatitis if the electrode is long enough to pass up over the vesicles.

In both specific and non-specific cases of prostatitis, the results of treatment are practically the same. There are undoubted reasons to believe that the action of the current applied in this manner forces out of the glands and vesicles all contained secretions and infiltrations, including probably the gonococci that may be lurking there. This observation is made from practical experience, after having treated several cases which have been entirely cured after a few weeks' treatment and have not recurred. The applications of these high-potential currents, which produce tissue contraction, set up a peristaltic action in the normal direction which tends to force the contents of glands, vesicles, and tubules outward through the natural channels of exit. It is by this process of expression, which is not otherwise produced than by electrical stimuli, with an associated consequent intense vibratory action, that the gland becomes entirely freed from all irritating and infiltrating substances, and the normal circulation is restored. There is nothing doubtful or uncertain in this action. It is a mechanical process and absolutely free from danger.

Concerning the non-specific cases there is no question as to the complete restoration of the gland to a normal condition if degeneration has not supervened, except that the hyperplasia which is present and has been produced prior to the institution of treatment will persist. Hyperplasia, however, only acts as a redundant material producing a relative degree of obstruction, but having no dis-

position to again take on an inflammatory action, and later often becomes less marked.

The following cases will illustrate the results of this plan of treatment of the different types at different ages :

Mr. G., age 63, came to me in June, 1901, in a state of great depression, stating that for four years he had been obliged to rise several times each night to void his urine, the passage gradually becoming more difficult; that during the previous weeks the urine had become very offensive and that he had been unable to retire at all on account of the necessity of continually rising, owing to the vesical irritation. Examination of the urine showed the reaction to be alkaline, of very offensive odor, and to contain quantities of mucus as well as numerous pus cells.

The treatment consisted of the daily administration of the static wave-current by the method described above for periods of twenty minutes. At the first treatment the pain, due to induced contraction, was so severe during the application that a current measured by a one-inch spark-gap was all that could be employed at the beginning. At the close of the treatment, however, the spark-gap had been increased to about four inches. The sense of relief after this treatment was remarkable. After four daily administrations, the patient was passing urine with greater freedom and the character of the urine was much improved. These treatments were continued daily for two weeks, and on alternate days for one week longer, when the condition of the patient was so much improved that treatment was discontinued. No local treatment was employed except the static wave-current applied to the

patient lying on his side with the straight rectal electrode shown in Fig. 26. Internally he continued to take for a vesical antiseptic a preparation of saw-palmetto which he had been taking. The patient for the last three years, and without any subsequent treatment, has been able to void urine without difficulty, has had no recurrence of the trouble, and has not been obliged to rise during the night to void urine, as had been his habit for four years previous to treatment.

It was this case, with all the difficulties that were present, that gave the writer great confidence in the possibilities of this method of treatment. In no similar cases or



FIG. 26. Rectal Electrode.

those of a milder type has the method failed since the treatment of this patient.

Another case will illustrate the results with a patient in whom the specific history was well marked.

Mr. —, age 32, a druggist, called in March, 1902. He gave a history of gonorrhea for a year previous, since which time he had had a great deal of trouble owing to prostatitis, which had been established during the first year. His sexual function was impaired. He was compelled to void urine very frequently, and had all the discomforts and depressed mental and physical conditions of the sexual neurasthenic. For more than a year prior

to his coming under observation, he had been unable to hold any permanent position which required him to remain on his feet for twelve hours. When he came for treatment he was very dejected and disconsolate—in despair—as is so commonly the case with these sufferers. The irritation of the bladder obliged him to rise from four to six times each night. No examination was made to demonstrate the presence of the gonococcus, but it is fair to suppose from the history that they were present. Treatment was administered daily according to the method above described, and from the first his improvement was marked. At the end of ten days he was able to secure a position as clerk, and to fulfill the requirements of his profession. At the end of twenty-five days he was discharged as cured and no subsequent treatment was necessary, having recovered all his functions with ability to pass his urine with freedom. This patient was seen two years later and there had been no recurrence.

In the first case reported there was absolutely no specific history, and in both instances these patients, as all others treated (fifteen in number), have made prompt and satisfactory recovery. One other case will illustrate more forcibly the results in the specific cases from which we may anticipate the greatest difficulty.

Mr. F., age 53, came under observation with a prostate three times the normal size. There was great difficulty in voiding urine. His sexual powers had been absolutely lost for six months, and there was great mental depression. The prostate was hard but somewhat compressible, and painful on manipulation. The patient had had gon-

orrhoea four years previous to the institution of treatment. The wave-current was administered with the straight rectal electrode held firmly against the prostate, the patient lying upon his side upon the static operating chair. A one-inch spark-gap was as long as would be permitted on account of pain at the commencement of the first treatment, but was increased to three inches before the close of the administration. After the first treatment, an examination was made, and the gland was found to be materially softened and reduced in size. These treatments were continued daily, and after the fifth treatment the gland was reduced to less than one-half the size at the outset, and the patient had recovered his sexual power and was passing urine much more freely. After ten days the administrations were made on alternate days, and at the end of three weeks the patient discontinued treatment, but called subsequently two weeks later to report himself to be in a normal condition, passing his urine freely, and otherwise generally normal. The gland remains somewhat enlarged, indicating the presence of a small degree of hyperplasia. Conditions are otherwise normal.

These cases are sufficient to demonstrate the method of action and results of treatment. We believe there is no method of treatment to-day that offers so much, nor which is so free from danger and inconvenience as the above method. In each of the above cases the straight rectal electrode shown in Fig. 26 was employed.

Others with whom the writer has been in communication have obtained the same uniform results from the

administration of the vacuum tubes placed directly in contact with the prostate.

The electrode shown in Fig. 23 was designed for treatment of tonsilitis and lengthened and adapted by Dr. Edward Titus, who has obtained perfectly satisfactory results in the treatment of prostatitis with the vacuum tube connected directly to the positive side of the static machine, the negative having been grounded. It is certain that the vacuum tubes in specific cases offer an additional advantage from the effects of the fluorescence upon the gonococcus and may be wisely employed from the urethral side. In cases that resist treatment, and particularly those in whom the urethral passage offers considerable obstruction to the passage of the urine, the wave-current may be administered to advantage by the use of the urethral sound placed in the urethra as an electrode. As large a sound as can be conveniently passed should be used. A wire attached to the upper end of the sound and connected to the positive side of the machine is all that is necessary in the way of preparations for this plan of treatment. The patient should sit up and hold the sound in position during the administration. The fact that it is possible to apply the high-potential currents to both sides of a structure so small as the prostate gland assures success in relieving the local congestion, and restoring the normal circulation and functions to the organ, except in extreme cases.

Orchitis, acute or subacute, may be successfully treated by the employment of the wave-current, placing either a very wet sponge electrode saturated with a salt solution,

in contact with the gland, or by carefully molding a tin-foil to its surface and securing it with a bandage, or by the application of the glass vacuum tubes or the brush-discharge over the inflamed organ. This method of treatment, associated with other recognized methods of procedure, is promptly successful in removing the inflammatory process, and relieving the suffering of the patient.

Epididymitis may be treated in exactly the same manner with the same measure of success. In specific cases, however, either of orchitis or epididymitis, the prognosis is not quite so good. The additional use of light applied from the arc light is useful in some of these cases.

Urethritis. Specific urethritis is relieved by the employment of the vacuum tube in the urethra, after the acute stage has subsided. In these cases the danger of carrying the infection into the deep urethra calls for the greatest caution in the application of a method which is otherwise practically a specific. The discharges of nitrous acid and ozone from a urethral vacuum tube, which is large enough to distend the mucous membrane, with the added effects of the fluorescence, will practically destroy the gonococci that come in contact with the tube. This method of treatment, however, should follow a thorough douching. When hemorrhage occurs as a complication of specific urethritis, it is evidence of the presence of an ulceration of the mucous membrane which is the forerunner of a stricture. The indication then is the application of vacuum tubes. (See Fig. 27.) Under these conditions, probably no means, to the present time, offers as certain prospects of healing ulceration without the sub-

sequent formation of organic strictures as the vacuum tube, for, as frequently stated in this volume, by relieving induration, ulcerations will promptly heal without the production of scar tissue. The operator must always bear in mind, however, the danger of carrying the infection higher up, and during administrations never pass the electrode into the deep urethra. The fact that the discharges are given off from the surface of the vacuum tube



FIG. 27. Set of Urethral Vacuum Tubes.

to the extreme end, somewhat precludes the danger of carrying infection higher up if held in position at the highest point to which the electrode is carried, assuring the disinfecting action of the discharges as far up as the tube is passed. It will be necessary in the use of those

tubes during the acute inflammatory stages of a urethritis to cocainize the urethra before the administration in order that it may be possible to pass the largest-sized urethral tube admissible, thereby smoothing out the rugæ and making it possible to bring the disinfecting discharges in close contact with the germs.

In cases of gleet the ulcers which are usually present back of a stricture may be healed by the use of the vacuum tube. This, however, is not suggested as good treatment, unless the stricture is also properly treated as soon as the ulcer is healed. It is best, however, to cure this ulceration by employing the largest tube that will pass before instigating the treatment of the stricture, especially if the continuous current is to be employed.

Spasmodic stricture of the urethra can be promptly relieved and cured by introduction of metal sounds while the current is administered, the tissues relaxing ahead of the sound as it is passed into the urethra. The patient should be instructed how to pass the sound, and then during the administration by holding it against the stricture, while the wave-current is administered, it will promptly pass. A few administrations of this sort, continuing the administration each time for fifteen or twenty minutes, will relieve the disposition to spasm, if not of central origin.

These methods are not at all adapted to the treatment of organic stricture, this field belonging to the methods by dilatation, or what is better in skilled hands,—the employment of the negative pole of the continuous current, by the Newman method.

Relaxed conditions of the pelvic viscera are effectively relieved by the general tonic effect of the wave-current as administered in the different cavities of the body according to indications. The tissues are thus restored to normal conditions of function and circulation.

CHAPTER XIV

THE APPLICATION OF HIGH-POTENTIAL CURRENTS TO GYNECOLOGY

THE diseases of women to which these currents are adapted may be classified as simple inflammatory conditions arising from: (1) childbirth, aggravated hyperæmia due to lacing, mental strain during adolescence, carelessness during the menstrual period, and incidental causes; (2) to spasmodic contractions and local stasis, often associated with the preceding conditions, which may seriously affect pelvic circulation, inducing (a) general hyperæmia with enlargement of the uterus and (b) coincidentally ovarian congestion; (3) specific diseases, the most prolific cause of female suffering; (4) other conditions affecting general health, notably constipation, anæmia, or malnutrition from any cause.

The high-potential currents associated with the correction of hygienic conditions, will go far towards relieving many of the above affections, if employed before the conditions have progressed to the stage of hyperplasia, or the development of pus and adhesions. The latter are unaffected generally by these modalities. Infiltration, simple hyperæmia and congestion, and the coincident conditions which arise, as muscular spasm, pain, swelling, and stasis with sense of weight, can be generally relieved

by their employment. Hyperplasia as present in fibroid and other organized tissue, the product of inflammatory conditions, may be arrested and the tissues made to contract at almost any stage, if the application of the high-potential currents can be brought in close relation to the affected structures. The necessity of producing a degree of tissue contraction and at the same time restoring generally the normal circulation of the parts, is the indication in these conditions. The successful removal of the local irritating influences associated with stasis which induce these abnormal tissue developments will depend upon the ability to bring a proper electrode into close proximity to the parts involved.

Conditions characterized by muscular spasm and consequent pain are, as a rule, associated with some congestive process in another part of the organ or an associated organ. It is, therefore, important to locate and diagnose the source of irritation, which is the remote cause of an inflammatory process, if the use of the high-potential currents is to be successful.

The treatment of infected conditions to be effective necessitates the administration of the current in such close relation to the tissues that the discharges, antiseptic in character, together with the effects of the light, as produced by the vacuum tubes, can destroy them. *In the early stages of congestion* before the formation of a pus cavity, when the infective element is present to a small extent, the induration is dissipated and an increased local leucocytosis is induced by the stimulating effects of one of the high-potential modalities carrying away the

infection and restoring normal circulatory conditions. This is well demonstrated in the treatment of local abscesses elsewhere, as suggested in Chapter X in the treatment of tonsillitis, whitlows, and carbuncles. When a pus cavity is already established, however, evacuation is imperative. In gonorrheal conditions, the vagina after thorough douching should be distended so that the rugæ will be stretched out, permitting contact with the discharges from the vacuum tubes to the whole surfaces which may be infected. The radiations from the vacuum tubes, it has been claimed by some writers, will penetrate the mucous membrane to the depth of two millimeters, or more. One other effect produced by this current will facilitate the relief of infected conditions, that is, the production of muscular contraction in the tissues, expressing the contents of the glands into the channels by which they may be eliminated or voided. This has been demonstrated effectively in the treatment of prostatitis of specific character as shown in Chapter XIII.

Muscular spasm may be relieved by the application of these modalities in two ways—(1) by the relief of processes of congestion which is the primary cause of the contraction, and (2) by exhaustion after a prolonged administration, during which the parts are in a state of tonic contraction. The former is most effective because inflammatory conditions are the common cause of contractures.

It will be seen that the *character* of the action of the high-potential modalities is rational, and fraught with no danger except when the contractions might possibly

produce the rupture of a pyo-salpinx into the peritoneal cavity.

Passive hyperæmia of the sexual organs arising from self-abuse or excitement, often associated with menstrual disturbances, functional in character, may be generally



FIG. 28. Set of Vaginal Vacuum Electrodes $1\frac{1}{2}$ to $\frac{3}{4}$ inch in Diameter.

relieved by the correction or removal of the cause and the employment, either of the wave-current with a long metal rectal electrode placed in the rectum and pressed forward against the uterus, or with a special vaginal electrode, either the glass vaginal vacuum one (see Fig. 28) or one

having an insulated part adapted to the cervix and posterior fornix (see Fig. 29), the vaginal portion may be of vulcanite. When administering the wave-current in the treatment of these cases, the application should be made for at least twenty minutes in order to produce a profoundly inhibitory effect upon the tissues. The application of the metal rectal electrode in the manner as described above (Fig. 26), is capable of relieving many cases of dysmenorrhea arising from spasm at the cervix by relieving the congested condition of the organ. In



Fig. 29. Vaginal Vacuum Electrode, Metal Insulated except at Cervical End on Fornix.

obstructed conditions due to a flexion which has occurred, these administrations are of less avail. If treated before the stage of congestion is followed by a relaxed condition, which is the occasion of flexion, such malformation of the organ may be prevented, and the patient saved from a life of suffering and sterility. Flexion can never occur in a normal, healthy uterus prior to a condition which in its early stages might have been prevented. The importance of administering such means, during the early menstrual life of the patient at the first suggestion of disturbance, cannot be too strongly urged. It is for young girls that the rectal administration of the wave-current is a valuable discovery. The writer's experience leads him to put particular stress upon the employment of the current in this manner.

Another method of overcoming congestions, particularly of the lower segment of the uterus, is by application of the glass vaginal electrode shown in Fig. 28, or



FIG. 30. Special Vaginal Vacuum Electrode for Retroversion Cases.

a similar metal one. These electrodes may also be adapted to the various malpositions of the different degrees of retroversion as shown in the accompanying illustrations. The one shown in Fig. 28 is designed for ap-



FIG. 31. Special Vaginal Vacuum Electrode for Retroversion with Prominence for Treating Urethrocele.

plication where the relations are normal, Fig. 30 and Fig. 31 are designed to come in contact with the cervix when a degree of retroversion is present, and Fig. 32 is adapted to an extreme degree of posterior displacement.

Another method of relieving pelvic congestion is by the application above the pubes of a metal electrode adapted to the form of the lower abdomen. The administration of the wave-current by this method is capable of very materially relieving various conditions in this region of congestion or abdominal relaxation. In the treatment of fibroid of the uterus this method of application induces

to slight degree contraction of the mass of the tumor, relieving in a measure pain and pressure. Such applications produce no other effect upon the tumor, except in favorable cases abating the progress of the growth. It does not, however, set up a process of involution, as seems to be the case when the X-ray is applied to uterine fibroids.

Administrations may be made with the static induced current in the manner shown in Plate I, Frontispiece, with an abdominal electrode placed in position at the same time that the glass vacuum tube is employed internally.



FIG. 32. Special Vaginal Vacuum Tube for Application to Cervix and Anterior Fornix.

When this is done, it is possible to regulate the action of the currents to the two electrodes by employing Leyden jars of different sizes. If beneath the electrode, over the abdomen of a patient, the muscles begin to contract before there is a positive sense of vibration from the glass vacuum tube in the vagina, place a small Leyden jar on the side connected to the abdomen. The larger Leyden jar will generally be required on the side with the vacuum tube. By making selections from three sizes of Leyden jars it will be possible to produce satisfactory local effects. In this connection we repeat, that it is important that the spark-gap be regulated to produce a distinctly vibratory sensation beneath both electrodes in order to

produce the desired physiological effect. The frequency of discharge not exceeding 120 to 300 per minute is calculated for the relief of congested conditions as shown elsewhere. It is the vibratory action associated with muscular and tissues contraction, so often referred to in this work, that enhances the effects of the application of high-potential currents.



FIG. 33. Vacuum Electrode for Intra-Uterine Application.

For application to the interior of the uterus an electrode is shown in Fig. 33 which is made of thick glass, which may be placed to the fundus in the interior of a relaxed uterus for the purpose of producing either a more tonic contraction or a possible effect upon infection if present. These methods will not preclude the necessity of the employment of curettage when retained secundines present demand removal. It is probable, however, that in the treatment of other disease of the endometrium, while it may be valuable in relaxed conditions, it should not supplant the employment of the continuous (galvanic) current.

CHAPTER XV

HIGH-POTENTIAL CURRENTS IN DISEASES OF THE EAR, NOSE, THROAT, AND EYES

THE affections under consideration comprise generally catarrhal processes of the mucous membrane. In addition there may be extensive inflammations of the sub-mucous tissues with infiltration and hypertrophy of the parts, resulting frequently in ulceration or necrosis. Abscesses may also occur in the serous tissues and the glands of these parts, as in suppurative tonsilitis, otitis media, and furuncles of the external auditory canal.

Functional or organic derangements, as they arise, either belong to or lead on to inflammatory conditions. These have been demonstrated to respond generally to the administration of high-potential currents. The causes of catarrhal inflammation are prevalent in moist climates and in crowded communities, where the atmosphere is full of irritating substances, hence there can be no expectation of obtaining more than temporary results. The indications, however, are treatment directed especially to the relief of congestion which may occur in the glands and also of hypertrophic and ulcerative affections before the development of bone necrosis.

Hypertrophic rhinitis and other hypertrophies of the mucous membrane which finally result in ulceration and tissue necrosis, obstructing the air passages, arise from

extreme degrees of local congestion, often the effects of neglect of attention to simpler lesions of the mucous surfaces. Some individuals are particularly prone to such affections.

The vacuum-tube electrodes connected with a source of high-potential electricity, coil or static, afford a safe and efficient means for alleviating infiltration and primary congestion, thereby preventing the later conditions which are apt to follow. The repeated application of astringents serve only as local and extemporizing agents contracting the superficial layers of the tissues, and producing a temporary condition of local stagnation without stimulating normal function. It is not so with the application of the vacuum tubes. They produce depletion by an energetic and tonic action upon the surface and deeper tissues of the mucous membrane, rendering the action of the muscles, nerves, and excretory system more active in their functions, at the same time relieving areas of local stasis, thereby restoring to a state approaching normal. To derive these benefits, however, from this form of administration, requires considerable time and patience during the administration. The vacuum electrodes must be brought in contact with the tissues for periods of five to ten minutes daily—at least every second day. The conformation of the parts of the posterior nares and extent of the lesion may often tax the patience of both patient and operator. The final success, however, fully justifies the outlay.

The application of these electrodes, if properly administered, is productive of no pain or disagreeable sensa-

tion to the patient. The Schneiderian membrane is but slightly irritated by contact with the surface during the passage of the current. If care is exercised to place the electrode in position, having first attached the conducting wire to the static machine, from one side, the other having been grounded, the operator should then gradually open the spark-gap to a point where the effect begins to be slightly disagreeable. The vibratory effects from these currents as derived directly from the static machine are peculiarly beneficial in the treatment of inflammatory conditions of the mucous membrane because of their known induction of tissue contraction and local vibration. Excellent results, however, are obtained in these cases from vacuum tubes connected either directly with the coil, or the resonator, or special high-frequency apparatus. When connecting directly to a powerful coil, it will be necessary that very little current is passing through the primary, lest the application be associated with too great heat, or too much local irritation will arise from the chemical action induced. It is better, therefore, when using a static machine that the vacuum tube be connected to the machine, i. e., no resonator should be employed. The results of treatment by these methods where there are extensive regions of infiltration with more or less obstruction of the posterior nares, will be found very satisfactory, and if applied with the requisite thoroughness will restore to normal extensive hypertrophic processes and prevent a subsequent necrosis of the turbinated bones, which so often follows. When ulcerations have resulted as a consequence of a hypertrophic process, there

are no means, we believe, so effective in promoting the healing of the ulcer as the systematic application of high-potential currents with the glass vacuum electrodes. These electrodes may be made in many forms for adapta-



FIG. 34. Various Curved Vacuum Tubes for Nasal Treatment.

tion to the various surfaces. Vacuum tubes for application to the turbinates are made having flat lateral surfaces, and may be variously curved that they may be brought in contact with the surface that may be involved as shown in the accompanying cut (Fig. 34).



FIG. 35. Eustachian Electrode.

These vacuum electrodes are readily manufactured of various shapes, from drawings to suit the ideas of the operator.

Figs. 35 and 36 are designed for applications to the turbinates and mouth of the Eustachian tubes.

Electrodes have been designed by the author for treating the posterior pharyngeal walls, provided with an open glass portion of the tube blown over the vacuum part, which serves to insulate, preventing induction, and painful and unpleasant discharges to the teeth when making applications through the mouth, for otherwise vacuum tubes may produce very disagreeable sensations. Even with this shell of insulation it may often be necessary to place a thin piece of rubber tissue over the tube when

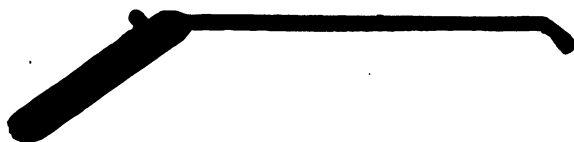


FIG. 36. Electrode for Treating Turbinates and Meatus of Eustachian Tube.

making the administration to sensitive patients, as there will be some induction and painful effect if they chance to touch the teeth when considerable current is passing.

Three forms of electrodes for application to the *posterior nares* are shown in Fig. 37. The surfaces of the electrodes for use in contact with the pharyngeal wall would be much larger, but it is a difficult problem for the glass-blowers to construct a tube of this shape having a broad surface at the extremity for making application extending up behind the velum.

For application to the tongue and tonsils Fig. 23 is beautifully adapted. It is indicated in the treatment of infiltration and hypertrophy of the tonsils and in the early stage of acute, suppurative tonsilitis, which the

employment of this electrode and the application of the brush-discharge externally will abort in the first stage of congestion.

The future employment of the vacuum tubes with high-potential currents in the treatment of various nose and throat conditions will suggest from time to time forms of tubes better adapted for meeting special indications. The

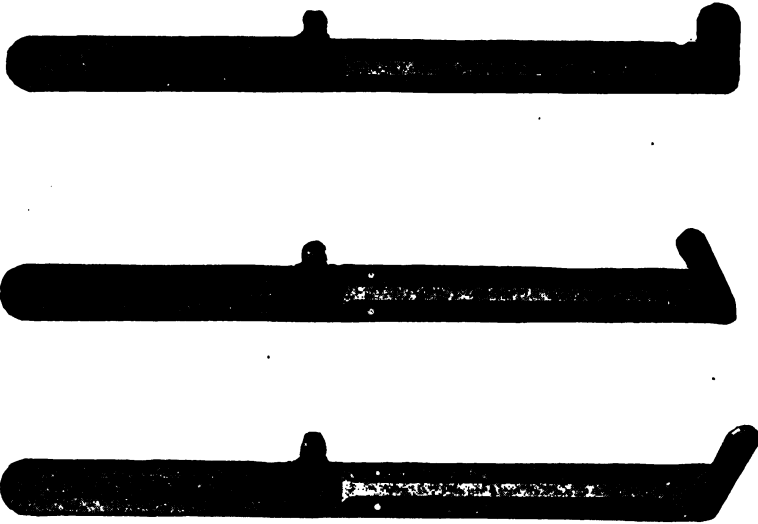


FIG. 37. Insulated Post-nasal Vacuum Electrodes.

ones shown have been designed by the author to meet conditions as they have arisen in his office and clinic.

For treatment of the meatus of the Eustachian tube, the vacuum tube, a cut of which is shown in Fig. 36, was designed for relief of the patulous and congested condition associated with some cases of deafness.

The sleeves for use in connection with the brush-dis-

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charge over the insulated end of the stick are shown in Fig. 12. They may be used for making application within the mouth and ear, and may be conveniently applied to other cavities and clefts.

Another electrode for application through the external meatus of the ear is shown in Fig. 38. *This insulated ear electrode* is provided with an *insulated shell*, having a tube extending over the extremity for making applications to the membrana tympani and middle ear through the external meatus.

Three sizes of vacuum tubes shown in Fig. 39 are de-

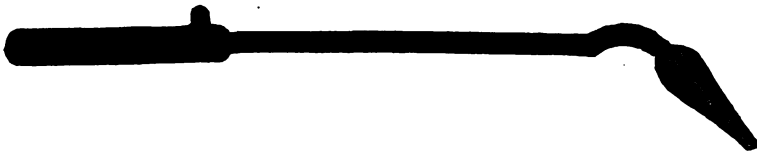


FIG. 38. Insulated Ear Electrode.

signed for treating furuncles in the external meatus. When applied early, suppuration will be aborted.

In diseases of the eye, especially in inflammatory conditions and conditions of strain and tension as well as superficial septic affections and conditions arising from poor metabolism, the currents of high potential have an important place.

An electrode has been designed for the treatment of the eyes, as shown in Fig. 40. This electrode is placed over the eyelids and even pressure made against the eyeballs. When the static machine is used the current should be taken directly from the machine. In ulcer of the cor-

nea, eye strain, and defective conditions of nutrition of the eyeball, the application of this electrode affords remarkable relief. The headache associated with straining or tension of the ciliary muscle arising from overwork or slight errors of refraction is promptly relieved. The *modus operandi* will be appreciated by those who have read the previous chapters of this book. For the above



FIG. 39. Vacuum Tubes for Treating Furuncles of External Meatus.

purpose applications should be used as often as indicated for periods of five or ten minutes.

In ulcer of the cornea, if the eyeball is cocainized, a soft administration of the brush-discharge from a pointed terminal may be applied over the ulcer, as to any other portion of the body, and will stimulate the local nutrition and is more likely to heal without the

production of scar than by any other method. When there has been an injury of the conjunctiva over the field of vision, if carefully treated during the reparative process by daily applications of the brush-discharge, the scar will be reduced to a minimum.

The author's experience when treating a case of eczema with the soft resonator spark, which involved the whole of the forehead over the left eye, in which the skin beneath the eyebrow was also involved, is worthy of noting here. The patient, a nurse, about 65 years of age, had

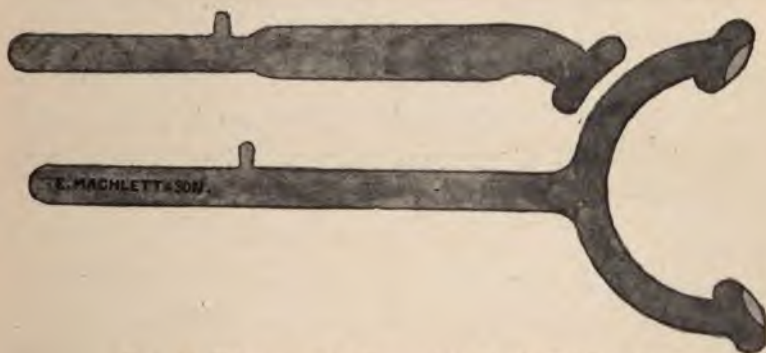


FIG. 40. Vacuum Eye Electrodes, Single and Double.

an opacity of the lens of the left eye, which had been diagnosed as an unripe cataract. During the application of the resonator sparks to the eczema they were often discharged over the eyeball as well as over the affected surfaces. To our surprise in about four weeks the opacity had disappeared. This instance is related only to suggest the possibility of a larger scope of application of these discharges than might be at first anticipated.

In the early congestive stage of an optic neuritis these

currents probably afford a greater field of opportunity for success than any other measure.

In conjunctivitis and trachoma there is also a field of possibility from these types of administration. In trachoma the application may be made by first cocainizing the conjunctival surfaces and then with the flat nasal or especially designed vacuum tube, make application thoroughly over the affected surfaces, moving the electrode about without removing it for five or ten minutes. The success from this method has already been fully demonstrated. In affections of the lachrymal secretion, application of the special eye vacuum tube will restore the conditions to normal in most cases. In early cases of acute obstruction of the lachrymal duct, applications, over the canal, of vacuum tubes will be followed by a happy result.

CHAPTER XVI

DISEASES OF THE SKIN

WHEN it is appreciated that currents of high frequency produce their greatest effect on the superficial structures, and that the influence upon the structures is largely mechanical, stimulating, and escharotic, the scope of indication for the treatment of diseases of the skin by the various high-potential modalities will be appreciated. Probably there is no one means, except possibly the X-ray, which should generally be used in conjunction with these currents, that possesses greater possibilities in the treatment of diseases of the skin than these modalities. The day for the application of ointments and lotions is passing, and no up-to-date dermatologist can ignore the importance of the uses of these agents in his particular specialty.

The conditions associated with the various diseases of the skin are due: (1) to errors of general metabolism or constitutional vices, (2) to local conditions, (3) to diseases associated with the presence of germs, fungi, or other parasitic forms of life in the skin, and (4) to other conditions associated with impairment or derangements of the nervous system.

Skin diseases arising from disturbances of general metabolism or functional vices include such conditions as acne, eczema, and psoriasis. When possible, it is de-

sirable to accomplish all that can be done by the employment of measures to aid in removing the causes. The use of the static wave-current with the electrode placed generally over the great abdominal viscera will offer much towards promoting the elimination and excretion of waste products from the system, as well as increasing the general activity of the skin. The employment of light and properly regulated baths accomplishes much in a general way for the relief and permanent cure of these conditions.

The local treatment, however, in such cases should not be neglected. Remarkable results have been obtained by the writer from the application of the brush-discharge and the short resonator sparks in the treatment of *psoriasis* and *eczema*. Chronic cases have been absolutely cured and not followed by a recurrence, indicative of a general condition. The *itching* is relieved in most of these cases from the first application.

In cases of moist eczema the resonator sparks or brush-discharge employed over the itching surface will cause the tissues to contract, causing the serous contents of the skin to exude, promptly relieving this irritating condition. The administration should be made thoroughly on every day or every second day, according to the demands of the case, at each application evacuating the serum present. Treatment by these means promptly restores tone and normal circulation to the tissues.

In psoriasis the application is made over the surface until the surrounding skin, which should act as a control, is distinctly reddened. These applications should be

made as a rule on every day, or not less often than every second day. The results from this application seem to be equal to those from the X-ray, which is also a valuable means of treating this affection. The only possible objection is the time required to make the application when extensive surfaces are involved.

In acne the indication is not for these methods except in the pustular type, in which also, as in the simple type, the X-ray is a more effective measure, causing the skin to become somewhat atrophied, abating the process by rendering the skin an unsuitable habitat for the germs which are characteristic of the pustular type. The resonator sparks, however, may be applied energetically over every new pustule of the pustular type and successively destroy each one until they cease to appear. This, however, is a painful process and not nearly so satisfactory as the X-ray.

The various local conditions such as *condylomata*, *moles*, *ulcers*, and *angioma*, may be successfully treated by the employment of the various high-potential applications, including the resonator spark, or other effluve from a high-potential source.

Condylomata (warts) may be successfully relieved by the application of the little sparks from either a coil or a static resonator, applying them until the growth is distinctly reddened. It will disappear generally in a few days after one application.

The treatment of moles is accomplished in the same manner as *condylomata*. It is necessary, however, to make the application fairly severe, to the extent even of

blistering. This may be done more properly and with comparatively less suffering by the application of the resonator sparks from the coil, as it is accomplished in less time, though the sensation is somewhat more severe. Following these applications there will be but little scarring.

The treatment of ulcers, except the syphilitic, by this method is usually a part of the routine treatment, and in most cases is all that is required to effect a successful result. The principles and indications for application, as explained in other parts of this work, are the relief of the induration surrounding the ulcer. For this purpose the application of the brush-discharge or the resonator sparks from either coil or static machine is effective. At each administration the application should be persisted in until the tissues are thoroughly softened in the hard and indurated zone surrounding the ulcer. This will permit the passage of the blood to the margin of the sore and the reparative process will be promptly instituted. The application also, of the same modalities over the surface of the ulcer will stimulate the metabolism of the tissue, acting at the same time as an antiseptic application. In some cases the application will cause the surface to exude considerable serum which is contained in the indurated margin or tissues of the ulcer, and also cause a contraction of the superficial layers of cells, leaving the surface coated by a film resembling a coating of collodion. Probably there is no method so well adapted to the treatment of ulcerative processes as these modalities, when systematically applied. The treatments can be repeated every

second or third day, and the promptness with which ulcers will generally heal will be surprising to those who have not heretofore been familiar with this method.

In specific ulcers the application is less effective and should not be used to the exclusion of the well-recognized internal specific treatment.

Angioma (port-wine marks) have been reported successfully treated by the employment of the resonator sparks from either the coil or static machine. The application should be made with sufficient energy to produce destruction of the outlying tissues involving the dilated capillaries and arterioles. These will separate in the form of scabs and will leave behind a peeled and comparatively white surface which will become later absolutely normal in color. Small areas may be treated at each sitting according to the toleration of the patient. This method of treatment is followed by much less scarring and destruction of tissue than the method by electrolysis and is to be highly commended.

The treatment of specific conditions including the two types of lupus, favus, sycosis, pityriasis, and others due to parasitic forms of life, is remarkably effective. In these conditions the antiseptic action both from the cauterant character of the applications and the production of the gases—nitrous acid and ozone—are destructive to the local cause *in situ*. In these conditions, however, the modality should be used generally in connection with the X-ray.

The application to lupus vulgaris and lupus erythematosus may be made with the static brush-discharge or

the resonator sparks from the coil or static machine; the former is much less painful. It may be desirable in some of these cases to carry the application to the extremity of cauterization, destroying the tissues involved. As a rule, however, it will not be necessary, if the modalities are employed in connection with the X-ray, to apply the current with the same severity.

In sycosis the X-ray should be pushed to the extremity of a first-degree dermatitis, after which the brush-discharge should be applied energetically until the condition is normal. With the falling of the hair from the X-ray, the success of the treatment will soon follow.

In epithelioma these modalities are not applicable except following the systematic administration of the X-ray when the surface has reached the point at which it shows no disposition to heal; the application of the brush-discharge or the resonator sparks will then stimulate the normal processes for periods during which the employment of the X-ray is suspended.

Local infection, as suggested elsewhere, may be treated by the cauterant application of the resonator sparks (preferably from a coil), thoroughly applied over the infected surface of the part involved, thereby destroying the local infection before it has become extensive. This should be done either on the first day or day following the possible infection, to be of avail, and may be wisely applied as a prophylactic upon suspicion from exposure.

To snake bites this method may be employed and is far superior to the application of lunar caustic or other cauterant applications.

In herpes zoster, in which the cause of the eruption is a form of neuritis, the application of the wave-current over the painful area before the appearance of the eruption will as a rule prevent its appearance. Later, however, when the eruption has appeared, the application of the resonator sparks from the static machine or coil or of the brush-discharge, will give great relief and hasten a return to the normal condition.

The applications of these methods to skin diseases would include a very much larger list of conditions than those mentioned here, but these will suffice as an outline covering the general principles of administration, and it will be found that there are very few, if any, skin conditions in which these methods of treatment will not be employed with success.

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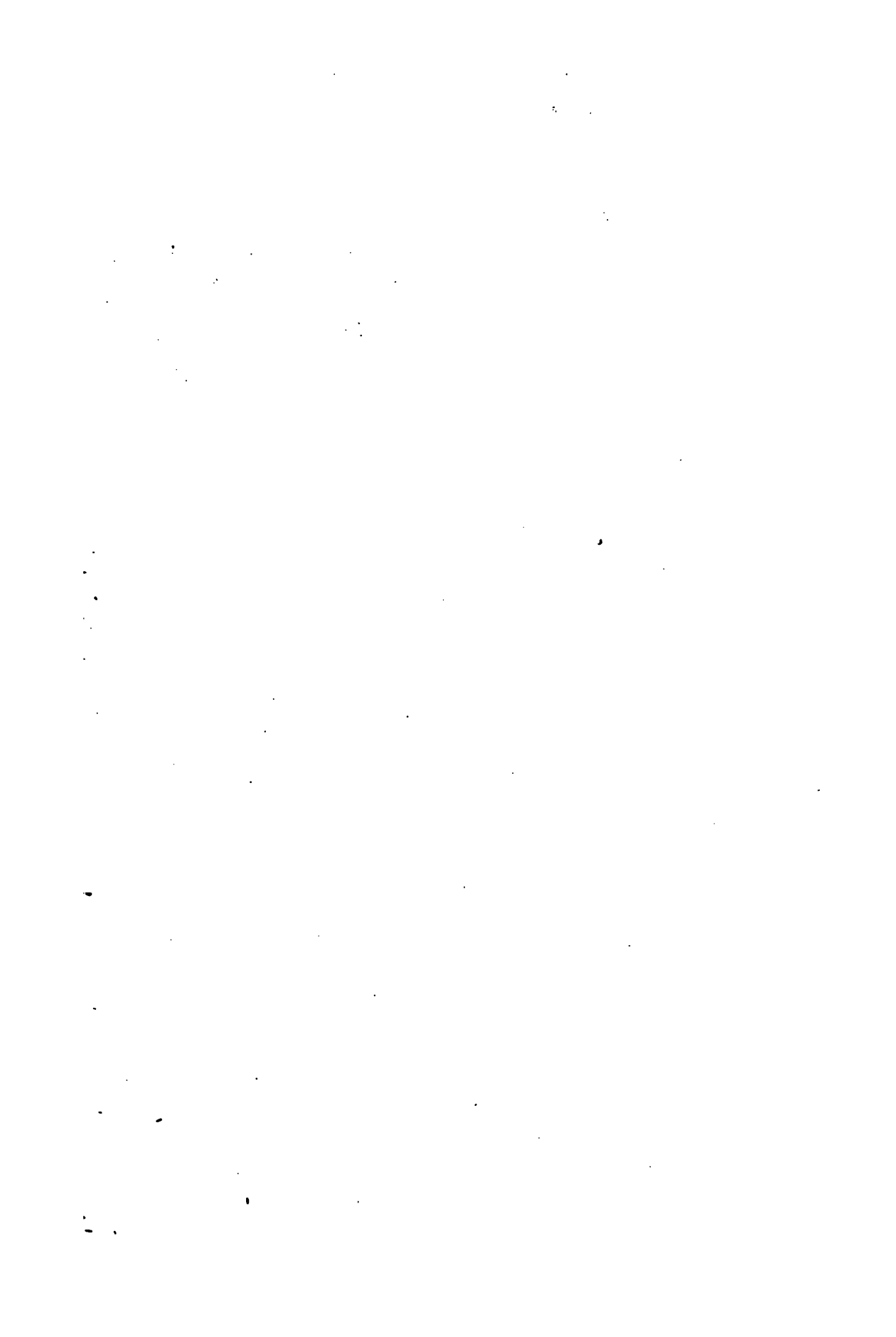
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